1985

A study for development and management of a maintenance management information system for Navy air-launched missiles.

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NAVAL POSTGRADUATE SCHOOL
Monterey, California

THESIS

A STUDY FOR DEVELOPMENT AND
MANAGEMENT OF A MAINTENANCE
MANAGEMENT INFORMATION SYSTEM
FOR AIR-LAUNCHED MISSILES

by

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June 1985

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REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) A STUDY FOR DEVELOPMENT AND MANAGEMENT OF A MAINTENANCE MANAGEMENT INFORMATION SYSTEM FOR NAVY AIR-LAUNCHED MISSILES		5. TYPE OF REPORT & PERIOD COVERED Master's Thesis June 1985
		6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) Richard B. Hancock		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS Naval Postgraduate School Monterey, California 93943-5100		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS Naval Postgraduate School Monterey, California 93943-5100		12. REPORT DATE June 1985
		13. NUMBER OF PAGES 96
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)		15. SECURITY CLASS. (of this report) UNCLASSIFIED
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Management Information System, Maintenance Data Collection System, technology transfer, technological innovation.

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This thesis examines the maintenance information system for the Navy's air-launched missiles, draws conclusions and makes recommendations on how a new information system should be developed and managed to enhance the capability of the Naval Air Systems Command to manage and support the maintenance of air-launched missiles in the next decade.

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A Study For Development and Management of a Maintenance Management Information System for Navy Air-Launched Missiles

by

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Submitted in partial fulfillment
of the requirements for the degree of

MASTER OF SCIENCE IN MANAGEMENT

From the

NAVAL POSTGRADUATE SCHOOL
June 1985

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LIST OF ACRONYMS

ALMs	Air-Launched Missiles
AR	Asset Readiness
AROs	Asset Readiness Objectives
AUR	All-Up-Round
AWCAP	Airborne Weapons Corrective Action Program
CAIMS	Conventional Ammunition Integrated Management System
CDCA	Central Data Collection Agency
CNO	Chief of Naval Operations
CPM	Critical Path Method
DBM	Data Base Manager
DBMS	Data Base Management System
DOP	Designated Overhaul Point
DPS	Distributed Processing Systems
DSS	Decision Support System
ECP	Engineering Change Proposal
EIRs	Engineering Investigation Requests
FLTAC	Fleet Analysis Center
FMSAEG	Fleet Missile System Analysis and Evaluation Group
ICS	Information Consolidation Services
IPG	Industrial Processing Guide
ILM	Intermediate Level Maintenance
ILSS	Integrated Logistics Support System
IMA	Intermediate Maintenance Activity
IRRP	Improved Rearming Rate Program
LCM	Life Cycle Management
MDD	Maintenance Due Date
MDCS	Maintenance Data Collection System
MIS	Management Information System
MLDT	Mean Logistics Downtime
MMF	Missile Maintenance Facility
MMIS	Maintenance Management Information System
MOAT	Missile On Aircraft Tests
MPI	Missile Pre-Sentencing Inspection
MSI	Missile Sentencing Inspection
NALC	Naval Ammunition Logistics Code
NARF	Naval Air Rework Facility
NAVAIRSYSCOM	Naval Air Systems Command
NAVSEASYSCOM	Naval Sea Systems Command
NAVSUPSYSCOM	Naval Supply Systems Command
NAWMP	Naval Airborne Weapons Maintenance Program
NIIN	National Item Identification Number

LIST OF ACRONYMS (CONTINUED)

OLM	Organizational Level Maintenance
SDAN	Source Data Automation Network
SIN	SPARROW Information Network
SIST	Serviceable-In-Service-Time
SLIT	Serial Lot Tracking System
SPCC	Ships Parts Control Center
SPS	System Performance Specification
PACMISTESTCEN	Pacific Missile Test Center
PMA	Program Manager, Air
PMS	Performance Monitoring System
PPBS	Planning, Programming, and Budgeting System
QDRs	Quality Deficiency Reports
RFI	Ready For Issue
TTL	Transistor-Transistor Logic
TPI	Test-Prior-to-Issue
WBS	Work Breakdown Structure
WEP	Workload Execution Plan
WLC	Workload Coordination
WQEC	Weapon Quality Evaluation Center

I. GENERAL INTRODUCTION

This report has been prepared to bring to the attention of the Naval Air Systems Command (NAVAIRSYSCOM AIR-420) deficiencies associated with its Management Information System (MIS) and the supporting Maintenance Data Collection System (MDCS) and make recommendations for their improvement.

A. BACKGROUND

NAVAIRSYSCOM (AIR-420) is the Navy's designated systems command responsible for the logistics support of Air-Launched Missiles (ALMs). NAVAIRSYSCOM (AIR-420's) function is the management (planning, programming, directing, and control) of field activities through specific delegated tasks to accomplish its mission. Since NAVAIRSYSCOM (AIR-420) does not own any missile maintenance or maintenance support activities, execution of these functions are assigned to other commands (e.g., supply to Naval Supply Systems Command (NAVSUPSYSCOM); maintenance to Naval Sea Systems Command (NAVSEASYSCOM). This separation of management and engineering from those activities performing supply support and maintenance is thus complicated by inter-command relationships. One such example of these relationships is MDCS. NAVAIRSYSCOM (AIR-420) has delegated MDCS to the Fleet Analysis Center (FLTAC), a NAVSEASYSCOM facility. NAVAIRSYSCOM (AIR-420) has had difficulty in controlling the operation and outputs of MDCS through delegated tasking, and FLTAC has been unresponsive in the execution of its function.

One of the more important missions of NAVAIRSYSCOM (AIR-420) is the accomplishment of maintenance and overhaul for the Navy's inventory of ALMs. This

inventory represents a large capital investment, with the annual maintenance budget estimated at 75 million dollars. The capital investment and support costs combine to form a significant ongoing business which is complex to manage.

The maintenance system has three levels: the organizational, intermediate and depot levels of maintenance. The organizational level is performed by the Fleet operational activities. Intermediate maintenance is performed by NAVSEASYSCOM weapon stations and Fleet Missile Maintenance Facilities (MMFs). Depot level of maintenance is performed by the Naval Air Rework Facility (NARF) Alameda and commercial companies. NAVAIRSYSCOM sets the maintenance policy for the organizational level, but the actual work is done by Fleet personnel. Intermediate level maintenance is primarily performed by weapon stations and is funded and managed by NAVAIRSYSCOM (AIR-420) with the actual scheduling and production accomplished by weapon station personnel. The same is true for depot level maintenance except the work is performed through contracting with commercial companies and by NAVAIRSYSCOM tasking and funding to the NARFs.

Timely and accurate information is essential to NAVAIRSYSCOM management and NAVAIRSYSCOM Fleet engineering support functions. The core of this information is maintenance data. NAVAIRSYSCOM (AIR-420) is responsible to the Chief of Naval Operations (CNO) for accomplishment of its mission. The performance of NAVAIRSYSCOM (AIR-420) is measured by Asset Readiness (AR) in terms of specified objectives called Asset Readiness Objectives (AROs). NAVAIRSYSCOM is expected to meet these objectives in the most economical manner possible (reduction of maintenance burden).

B. STATEMENT OF NEED

Inherent in the efficient accomplishment of the NAVAIRSYSCOM (AIR-420) mission is an efficient and credible MIS. It is essential that NAVAIRSYSCOM (AIR-420) and cognizant field activities have accurate and timely information from all the decentralized maintenance facilities and activities to efficiently accomplish their assigned mission. This accurate and timely information can best be gathered, collated, analyzed and compared to standards through the use of a modern MIS. The existing NAVAIRSYSCOM (AIR-420) MIS is antiquatld and has many deficiencies.

The development of an air-launched missile information system that is both modern and adequate would benefit the Navy in terms of asset readiness, reliability of inventory, and decreased cost of maintenance. Asset readiness would be increased by decreasing missile logistics downtime, thereby increasing the number of missiles in Ready For Issue (RFI) condition. Better engineering decisions would be possible for product improvement, which would increase inventory reliability. Rapid access to information would help management minimize costly delays and pinpoint uneconomical maintenance actions.

A modern MIS should have the capability to provide real-time reporting and analysis of all essential processes within the maintenance pipeline. A user should also be able to project the results of future maintenance processes based on qualitative or quantitative variables. The information supplied must be credible, understandable, and offer a reward for its use. Without these properties, the users will not accept ownership of the information and the system will fail. Ownership is best accomplished when the system is an integral part of the user's organization. The significant number of users require that any new NAVAIRSYSCOM (AIR-420) MIS be a distributed network of

computers so that all participants have equal access and share responsibility for the data and information. The final responsibility for operation and management of the information system should be within the NAVAIRSYSCOM (AIR-420) organization to prevent inter-command conflicts.

C. RESEARCH OBJECTIVES

This report examines the characteristics of the existing MDCS and determines its potential utility as the primary element in the development of a modern Maintenance Management Information System (MMIS). The objectives of the report are:

1. Determine and analyze characteristics and capabilities of the present MDCS and MIS.
2. Analyze the deficiencies of the existing MDCS.
3. Propose system properties and management guidelines for the development of a new MMIS.
4. Develop a conceptual model for a modern MMIS as the primary element of a modern MIS.

D. REPORT CONTENTS

The remaining portion of the report has been divided into six sections. Each of these sections is briefly described to orient the reader and assist in locating pertinent information.

Section 2 presents the major conclusions and recommendations of the report. Conclusions and recommendations have been included as early as possible in the report to allow evaluation with a minimum of effort. Justification is contained in ensuing sections.

Section 3 presents a more detailed background of Navy maintenance policy and the current NAVAIRSYSCOM (AIR-420) MIS structure as defined in OPNAVINST 8600., The Naval Airborne Weapons Maintenance Program [Ref. 1]. This material has been included to provide the reader with a background of basic

NAVAIRSYSCOM processes which may be necessary for the understanding of subsequent sections of this report.

Section 4 is a historical review of the MDCS which details capabilities and deficiencies. The historical approach was adopted in order to demonstrate how deficiencies emerged and to emphasize that they are persistent in nature. The persistence of deficiencies indicates that they are managerial rather than technical in nature.

Section 5 presents material of a conceptual nature concerning the characteristics required for a new MMIS. This section contains two subsections. The first describes technology transfer principles which should be applied in the development of a new information system. Although philosophical in nature, these principles are considered more fundamental to the successful development of a new system than technical requirements. The second subsection lists conceptual requirements of a technical nature for the new system.

Section 6 briefly surveys the state of current information system technology, and concludes that the primary potential difficulties in the development of a new information system are managerial rather than technological in nature.

Section 7 briefly describes a management systems approach which should be adopted for the development of the new system.

II. CONCLUSIONS AND RECOMMENDATIONS

The following ten subsections present the major conclusions and recommendations of this report.

A. MIS IS NOT FUNCTIONAL

The MIS is defined as a major system of the ILSS, which provides the capability for data gathering, analysis, display, and reporting in the management decision making process. The system consists of five components. However, in its current state the MIS is non-functional for the following reasons:

1. Some components are not operating;
2. Most components do not adequately fulfill their intended function;
3. All components do not interface properly;
4. Components do not combine to form an effective management information system.

PMS, ICS, and PRABS are currently not operational or have fallen into disuse. Only AWCAP appears to fulfill its intended function, but this subsystem would benefit from modernization. In a systems sense, none of the components interface properly. For example, AWCAP and PRABS are stand alone systems. PMS and ICS were clearly designed with the primary purpose of interfacing MDCS with MIS. Their failure isolates MDCS and makes access unfeasible. An effective MIS cannot be developed from components which do not operated to fulfill their intended function or interface properly. Therefore, NAVAIRSYSCOM should begin restructuring the current MIS.

B. MDCS IS UNWORKABLE

Since the MIS is deficient as an information system, at least some of the components which combine to make up the MIS are accordingly unworkable. The

most important of these components, MDCS, has several serious deficiencies and should be abandoned as a means of monitoring air-launched missile status and history. Although the system basically conforms to the definitions published in the NAWMP, it has deteriorated into a useless mass of data, unintelligible to its users and developers. It is ultimately unworkable for the following reasons:

1. Users do not have direct access to data files;
2. Current report output is of marginal quality and reliability;
3. Users have little or no data processing capability;
4. Reliability of data element definitions is questionable;
5. System documentation is inadequate;
6. Timeliness of data entry is still in question.

More importantly, MDCS lacks credibility with users. The lack of user confidence has produced continual efforts to subvert the system and obtain data by other means. However, even if MDCS deficiencies could be immediately corrected, significant user support could not be generated within the foreseeable future. A management information system cannot survive without the support of its users.

C. DEVELOPMENT OF A NEW SYSTEM

Considering the deficiencies of the MDCS listed above, remedial upgrade of MDCS appears to be a more significant effort than development of a new system. The development of a new system would avoid the user bias and obsolete technology inherent in MDCS. The imposition of a systems approach with a phased implementation (including proper planning and evaluation) offers the highest probability of success.

The final goal of this development effort should be a completely restructured NAVAIRSYSCOM (AIR-420) MIS. The intent of this report is more limited in scope. The report recommends that MDCS be abandoned and replaced with a

new component called the Maintenance Management Information System (MMIS). The MMIS would be a stand alone information system for the management of ALM maintenance. Implementation of the MMIS will fill a critical need in itself. The MMIS would also serve as the cornerstone of the restructured MIS through expansion upward and outward until all requirements for management information of the ALM community are satisfied.

D. UTILIZATION OF TECHNOLOGY TRANSFER PRINCIPLES

The principles of technology transfer should be considered in the conceptual formulation of the MMIS. In a general sense, technology transfer principles are contained in nine elements of the Linker Model and are considered necessary for user acceptance of new developments or innovations. By applying technology transfer principles to information systems, the new MMIS becomes the linker between the members of the ALM maintenance community. Reward and penalty of the system should also be given careful attention. In the general sense, this means that there must be a reward for the use of an innovation or it will not be utilized. Consequently, products of the MMIS must offer a reward for their use to the members of the ALM community. The reward concept implies that MMIS conception starts with the definition of products as opposed to MDCS, which started with the definition of data elements. The MMIS must be product oriented.

E. MMIS TECHNICAL REQUIREMENTS

Research conducted in during the preparation of this report identified eleven technical requirements of a conceptual nature which should be incorporated in the MMIS.

1. The system must be controllable and auditable.
2. The system must have integrity.
3. The system should be economical to operate.
4. The system must be user friendly.
5. Data must be collected real-time as missile maintenance status changes.
6. Inquiries must be answered with up to the minute information.
7. The system must interface all users of the information with the suppliers of data.
8. Missile quality assurance and data quality assurance must be linked.
9. The system must be fail soft.
10. No special skills or extensive schooling should be required to run the system.
11. User programming should be optional.

In addition, the MMIS should incorporate a Data Base Management System (DBMS) and a Decision Support System (DSS). These systems would prevent data redundancy and support semi-structured decision making.

F. MMIS DISTRIBUTED NETWORK

The MMIS should be configured as a distributed processing system, composed of a host computer servicing a number of satellite computers. Each satellite would be able to transmit and receive data from the host computer, and update host data files on a selected basis. The satellites would also be capable of independent data processing and should be able to communicate with the other computers in the network. The host computer would maintain all present missile configurations, integrated maintenance histories, present maintenance status summaries, and pipeline location.

G. DEVELOPMENT OF A MISSILE TRAVELER

A missile traveler system should be developed. The traveler system recommended in the report follows the missile through the pipeline and integrates data collection, quality assurance, and maintenance status functions. The traveler would significantly reduce the paperwork requirements currently

imposed on maintenance personnel by eliminating missile log books, configuration summary forms, maintenance action forms, and maintenance check lists. Integration of the traveler package with quality assurance functions should also increase data accuracy.

H. PERFORMANCE STANDARDS

Performance standards should be incorporated in the MMIS processing software to allow automated management by exception. There is a need to quickly identify maintenance problems such as abnormal reject rates of assets, delayed processing times, excessive buildup of non-RFI inventories, and excessive logistics downtime. NAVAIRSYSCOM (AIR-420) developed a number of performance standards covering many aspects of ALM maintenance processing. However, implementation of these standards has been hindered by the inability to incorporate them in a viable MIS.

I. AVAILABLE TECHNOLOGY

The conceptual MMIS has no technical requirements which cannot easily be satisfied with existing technology. Therefore, selecting the appropriate technology becomes a trade off of existing technology options with their associated costs for optimization of the MMIS. The primary question will be between MMIS development and operation costs, and benefits to be achieved. The benefits should relate to asset readiness and the reduction of maintenance burden.

J. MMIS OWNERSHIP

NAVAIRSYSCOM (AIR-420) must maintain ownership and control of the MMIS to ensure the success of the system. From a practical standpoint, NAVAIRSYSCOM (AIR-420) cannot assume control of computer systems of other commands nor should it delegate the operation of its system to other commands. A field activity such as PACMISTESTCEN would be an excellent choice for the development of the MMIS since this activity is a primary user of ALM maintenance information. The MMIS should be developed and operated by the activity that it is primarily designed to support. In the author's opinion, this is an activity delegated responsibility for ALM maintenance management: PACMISTESTCEN. Three critical benefits are obtained by giving MMIS to its primary user. First, this user will strive to ensure system success because of the rewards offered. Second, the user is in the best position to integrate information system functions with management functions. Third, this user would be forced to accept ownership of the information and would thus eliminate controversy as to what information is pertinent.

III. DETAILED BACKGROUND

A. NAVY MAINTENANCE POLICY

The Navy's current maintenance policies follow three ideas: the All-Up-Round (AUR) maintenance concept, tri-level maintenance, and achievement of the ARO. The AUR concept attempts to deliver a missile to an operational squadron in the simplest, most reliable manner possible. Using the AUR concept, operational Fleet squadrons perform only minor assembly before installing the missile on the launch platform. In turn, the AUR concept allows shore activities to validate the status and condition of the missile with a minimal expenditure of labor, time, and money. The maintenance pipeline splits ALM maintenance into three levels. The extent of maintenance needed determines the number of levels required to ultimately accomplish repair.

The first level, Organizational Level Maintenance (OLM), encompasses the maintenance performed by Fleet operational squadrons. O-level maintenance generally consists of missile receipt, inspection, aircraft preparation, loading and downloading, basic functional aircraft checks, and installation and removal of wings and fins.

The second level, Intermediate Level Maintenance (ILM), encompasses the maintenance performed by an Intermediate Maintenance Activity (IMA): a Naval weapon station or MMF. The IMA supports the operational squadron by providing an AUR that is ready for launch except for the attachment of wings and fins. I-level maintenance personnel conduct AUR tests of the assembled missile and replace defective missile sections. Missile sections requiring maintenance beyond I-level capability are sent to the Depot level maintenance. In addition,

the I-level unpacks and inspects AURs and sections, and repacks them when testing and cleaning have been completed.

Depot Level Maintenance is conducted at activities called Designated Overhaul Points (DOP). At this level, individual parts and subassemblies are replaced in sections that failed I-level tests and inspections. In addition, special maintenance actions, such as the regraining of rocket motors, are performed at the DOP. Completing the maintenance cycle, the DOP provides the weapon station with repaired sections which are ready for assembly into an AUR.

Every year the CNO establishes the ARO, which serves as the goal to be achieved and maintained by the entire maintenance community. Asset Readiness (AR) is a fluctuating figure which specifies NAVAIRSYSCOM (AIR-420) performance of given missile inventory. It is expressed as the ratio between serviceable missile assets and the total numnber of assets in this inventory. Thus, the less time a missile spends in the maintenance pipeline, the higher the asset readiness figure.

The central point in the pipeline is the weapon station. Here, new missile sections from manufacturers are inspected and assembled into AURs. Fleet return AURs are also received for periodic tests and/or maintenance. After assembly and testing, or testing and maintenance, the AURs are packaged in containers for shipment.

AURs are provided to the carriers from weapon stations' RFI stocks. The missiles are generally loaded on board a service force ship and transported to the aircraft carrier where they are transferred by vertical replenishment and stored in magazines in their AUR containers. During a deployment, the carrier unpacks only enough missiles for self-defense, usually about twenty percent of the on board air-to-air missiles. Carrier deployments are approximately one year.

While returning to home port at the end of the deployment, the carrier will undergo a Missile Pre-sentencing Inspection (MPI), known as Missile Sentencing Inspections (MSIs) prior to 1979, which evaluates the serviceability of all missiles on the carrier, thus reducing processing at the weapon station. During the MPI, missiles are segregated according to another concept that is vital not only to the maintenance pipeline, but also to the MDCS itself. The concept of Serviceable-In-Service-Time (SIST) indicates the maximum period of time a deep stowed missile may remain in storage before it must be returned to a weapon station for periodic test. As will be discussed later, the concept of SIST significantly changed the Navy's maintenance policy.

Using SIST and the corresponding Maintenance Due Date (MDD), personnel conducting the MPI segregate serviceable missiles from the unserviceable. Those which were captive carried, have an expired MDD, or insufficient SIST remaining for another deployment are pre-sentenced to be returned for weapon station testing. Deep-stowed missiles which have sufficient SIST remaining for the next carrier deployment are crossdecked to another carrier. Hence, the MPI screens the serviceable missiles for Fleet retention rather than returning the carrier's entire inventory to the weapon station.

Those missiles which require processing are then moved to the IMA where they are tested as AURs. If they pass, they are returned to RFI storage. If they fail, the section causing the failure is isolated and replaced. The defective section is then shipped to the depot for overhaul.

At the depot the section is repaired and shipped back to the weapon station for assembly into another AUR or as a replacement spare. The time that missiles and missile sections are in the repair pipeline is determined by the efficiency of the maintenance system since individual test and repair actions

are accomplished in a matter of hours. The number of weapons in the pipeline at any one time depends on the number of missiles which are sentenced as unserviceable and the elapsed time required to return them to RFI condition.

B. NAWMP DEFINITIONS

In the early 1980s, NAVAIRSYSCOM (AIR-420) developed the Naval Airborne Weapons Maintenance Program (NAWMP), which serves to fully document maintenance policy for ALMs under the cognizance of AIR-420. This report examines the structure of AIR-420's management system, the Integrated Logistics Support System (ILSS), but concentrates on one ILSS element, the Management Information System (MIS) and its subordinating components. Definitions of the ILSS, MIS, and subsidiary subsystems have been extracted from the NAWMP in an effort to compare the way these systems were designed to operate and their actual operation today.

The ILSS [Ref. 2] was instituted in the early 1970s as a means of decentralizing AIR-420's logistics functions. The ILSS is comprised of five systems, the primary system being the MIS. As defined in the NAWMP, "The MIS provides a capability for data gathering, analysis, display and reporting which is used by management personnel in the decision making process" [Ref. 3]. The system consists of five components which together are supported to provide an automated maintenance monitoring capability. The first, the Problem Reporting and Briefing System (PRABS) is a "semi-automated management information, quick-reaction reporting system which provides procedures for collecting and reporting significant active problems and proposed solutions" [Ref. 4].

The Airborne Weapons Corrective Action Program (AWCAP) system is owned and operated by the Pacific Missile Test Center (PACMISTESTCEN). It is used to

accumulate and track maintenance deficiencies of all air-launched missile systems and selected airborne ordnance/ammunition commodities. Problems are reported through Quality Deficiency Reports (QDRs), Engineering Investigation Requests (EIRs), and Safety Reports submitted by Fleet and shore based maintenance activities. The AWCAP report summarizes all active problems and reflects the progress of the investigation, including any corrective actions taken.

The third MIS component is the Maintenance Data Collection System (MDCS), the primary maintenance data system for air-launched missiles. According to the ILSS, this system "provide[s] a single source of maintenance data to remote and local data users," and also "collect[s] and store[s] as much detailed maintenance data as can be reasonably obtained, while adhering to a simple, easy to understand data collection procedure" [Ref. 5]. As the Central Data Collection Agency (CDCA), FLTAC designed and distributes forms for recording and transmittal of specific information regarding each reportable action. In accordance with the basic precept of MDCS, data is hand written on the form.

As defined in the NAWMP, the last two segments of the MIS are two on-line data distribution systems presently operational at FLTAC. The Performance Monitoring System (PMS) has been designated as the "primary mode for presenting and distributing logistic management information" [Ref. 6]. The PMS maintains on-line displays available for logistics management users possessing remote terminal access. Through remote terminals, users can request summarized PMS data displays, including Mean Downtime, Part Replacement Rates, and ALM processing rates.

The second information distribution system, the Information Consolidation Service (ICS), has been established as a method of "deriving selected information by the user...from data stored in the Integrated Data Base" [Ref. 7].

ICS integrates the files of maintenance data with related reference files of supply oriented data. ICS outputs include summary reports and displays reflecting maintenance trends, reject rates, and average maintenance time.

Although the definitions and procedures of the MIS have been clearly outlined in the NAWMP, the system is inoperable for reasons that will be discussed in the next section of this report. The current Management Information System is not answering the needs of the Navy's maintenance community. The time has come to begin a change.

IV. HISTORICAL REVIEW OF MDCS

A. MAINTENANCE DATA COLLECTION SYSTEM

The MDCS component of the MIS was designed and is operated by FLTAC, formerly the Fleet Missile System Analysis and Evaluation Group (FMSAEG). Its development stems from the late 1960s as a response to OPNAVINST 4790., which called for an effective Maintenance and Material Management (3M) Program for air-launched missiles and targets. Although the NAWMP states that MDCS was developed as part of the ILSS, design concepts for MDCS predate the ILSS by an undefined period of time. Revision 2 of the ILSS Program Master Plan states that at the beginning of the program MDCS was "fully defined" and design (development) would begin immediately. At that time, the NAVAIRSYSCOM (AIR-420) organization was known as NAVAIRSYSCOM (AIR-4104). AIR-4104 began developing the ILSS in 1972 as a means of defining and systematizing ALM maintenance management functions. The ILSS program was instituted to decentralize and delegate authority of NAVAIRSYSCOM functions to cognizant field activities. Although in its infancy, MDCS was one of these existing functions.

B. MDCS CAPABILITIES

MDCS had originally been conceived as an entity in itself. At the time, however, little attention was given to the possibility of interaction between the various data systems of the MIS. Primary emphasis was placed on data collection, while data processing and information output were secondary considerations. Nevertheless, it was the ILSS which later defined MDCS as part of the NAVAIRSYSCOM (AIR-4104) MIS. As will be discussed later, little

effort was expended in restructuring MDCS itself. It was simply inserted as a component for the newly developed MIS. The additional requirements for interfacing data processing and information output components were imposed on the two new elements, PMS and ICS. This decision lies at the very heart of the controversies concerning the validity and utility of MDCS: does MDCS fulfill its design function?

The answer to this question is a hesitant yes, although with great difficulty and much uncertainty. PMS and ICS are acknowledged failures, and without any data processing or information output capability, MDCS cannot stand alone. Further, without these functions, the merit of the data within MDCS, and therefore the merit of MDCS itself cannot be rationally evaluated. MDCS is an antiquated system in dire need of revision. Its current lack of credibility and the significant level of user bias favors the development of a new system rather than extensive revision of the existing system. The technology available also makes it desirable to redefine the MDCS's function so that it becomes an interactive element of a future MIS network vice a data collection system.

C. MDCS DOCUMENTATION

Program documentation from the early period of MDCS development is scarce. However, interviews with individuals involved with ALM maintenance at the time indicate that a systems approach was taken in an effort to collect all pertinent data. MDCS was subdivided into three parallel subsystems to mirror the maintenance pipeline.

1. Shore Activity MDCS

The first and most important of the three subsystems was Shore Activity Maintenance Data Collection. The Shore Activity MDCS was designed to

collect data concerning maintenance actions on air-launched missiles at the weapon stations and MMFs (the current MMF is located at Naval Air Station Cubi Point).

2. Fleet Maintenance MDCS

The second level, Fleet Maintenance Data Collection, was designed to collect maintenance, quality surveillance, and logistic-oriented data on air-launched missiles in the custody of the operational Fleet, including Naval and Marine Corps air stations.

3. Depot MDCS

The third level, Depot Maintenance Data Collection, was designed to collect overhaul and repair data for all air-launched missile guidance and control sections being maintained at various NARFs and contractors. FLTAC achieved varying levels of success in the development and implementation of the three subsystems. Primary emphasis was placed, and the greatest amount of success was achieved, with the Shore MDCS subsystem. General references to MDCS are primarily directed at the Shore based MDCS subsystem.

D. MDCS DATA

In the early 1970s, FLTAC began surveying individuals involved with ALM maintenance to identify applicable data elements to be included in MDCS. A major mistake in the development of the system was made at this time. After interviewing maintenance managers and engineers, a great deal of "pertinent" data elements were compiled. However, very little consideration was given to the actual utility of each of these data elements, or how the elements could be combined to produce meaningful reports. In addition to the interviews, OPNAVINST 4790. strongly influenced the definition of data elements. For

instance, the instruction required that each individual missile program be idenified, along with a capability to interface with other missile related data programs. Routine and corrective maintenance had to recorded, in addition to referencing technical directives, and the establishment of logistic audit procedures.

These surveys resulted in two essentially standardized computer record formats. This first record format characterized maintenance actions, such as inspection, test, repair, and assembly of missiles and sections. The second record format characterized the configuration of built-up missiles. This included the part numbers of major components and service life information. Figure 1 lists data elements for the PHOENIX maintenance action record format. As can be seen, this record was long and complex. The PHOENIX maintenance action record contained 46 possible elements or fields with a maximum of 720 characters. The size and complexity of the record led to some of the problems encountered with MDCS. First, the record placed excessive demands upon the individuals who were supposed to record the data. Maintenance personnel considered missile maintenance to be their primary function and felt that data entry was an imposition. Second, some of the elements within the record could not be easily obtained on the weapon station floor. For example, the third data element called for the National Item Identification Number (NIIN), and would be skipped if it was not directly accessible to processing personnel. Elements such as the NIIN were probably meant to be completed at later stages in the data collection process. At any rate, the practice resulted in the generation of records with many missing elements.

A second problem involved with the MDCS records was that their size made physical inspection and comprehension difficult. Neither CRT displays nor

printers could provide the data in a single line format, making it very difficult to interpret. To compound the problem, software from the UNIVAC computer was used to compress the data. FLTAC programmers employed the symbol (@) as a means of condensing the record. For example, if the first two data elements in a record were the serial number and Naval Ammunition Logistics Code (NALC), and the third data element, the NIIN, was unknown, the record would look like this: @20125@PA55@@.

From the standpoint of data storage, this process had significant merit since these records could now be allocated a fraction of the space that they normally required. However, without some form of intermediary processing, the records became unintelligible. With 46 data elements, particular blocks of data were scattered at varying locations within the record. If ten consecutive data elements were skipped, for whatever reason, eleven consecutive symbols would be printed, making the actual data, what little there was, very difficult to read. This practice of data compression and the limited distribution of record format led to the development of an elite corps of FLTAC analysts who could translate the data. In effect, the data was scrambled and without relatively large machines and proper coding, it could not be deciphered.

E. MDCS DATA COLLECTION

Data collection for the MDCS subsystems was accomplished through multi-copy forms. Figures 2 and 3 are facsimiles of the forms used for SPARROW maintenance actions and configuration summaries for shore activities. It was originally intended that personnel directly involved with missile maintenance, afloat and ashore, fill out the forms, although this idea was quickly compromised. Carrier magazines were overcrowded and working conditions were poor.

Ordnancemen recorded the minimum essential data in pocket notebooks to be transcribed later to the MDCS forms by yeomen in Airborne Ordnance Control offices for eventual delivery to FLTAC. Naval weapon stations had developed their own paperwork (at first in the form of local worksheets and later as checklists adapted from particular maintenance manuals) to monitor their internal maintenance processing. Thus, the weapon stations considered MDCS paperwork as not only an imposition, but also needless. In addition, a substantial portion of the data on the forms was codified in order to standardize compression and facilitate data manipulation. Again, the codification was highly desirable, and to a certain extent necessary, but it produced an extremely unfriendly system. Few individuals knew what Julian date it was or what the Julian date would be in nine months, which was a required reporting element in many cases. Due to the codification and the additional paperwork, the weapon stations developed strong biases against MDCS.

As a result, the weapon stations began designating "specialists" to complete the MDCS forms. These individuals were sometimes stationed away from the processing floor and often lost some understanding of the actual maintenance being performed. Their job was simply to transcribe data from one form to another. But due to a certain apathy among processing personnel, inaccuracies often occurred during the translation.

As mentioned earlier, the basic MDCS data forms were in multicopy format using a carbon paper-like transfer process. Actually, the forms were impregnated with a transfer medium whose density was less than desirable since most copies were difficult to read. The configuration summary forms had one original, which was sent to FLTAC, and four copies. Of the copies:

1. One was included as documentation kept with the particular AUR or missile section;
2. One was kept at the weapon station missile maintenance processing building for approximately 90 days;
3. One was kept at the weapon station data processing offices for several years;
4. One was usually destroyed.

The copies acted as a safety measure to insure that data was not lost. The use and distribution of the copies had significant impact on future utility of the ICS module of the NAVAIRSYSCOM MIS. When troubles developed in ICS, weapon station personnel, maintenance engineers, and maintenance managers turned directly to these hard copy MDCS files for direct access to data. To this day, direct access to these hard copy files is one of the most valuable although unofficial sources of MDCS data. In a way, use of these files may have relieved some pressure on ICS since vital information was ultimately obtained and problems were solved. On the other hand, use of these files probably increased criticism of ICS, since users were quick to point out that the data was available but could not be accessed within FLTAC's data banks. It soon became apparent that if you dug hard enough, you could find the data you needed; but more importantly, FLTAC did not have the data in the MDCS.

F. DATA STANDARDIZATION

Considerable effort was expended to standardize data between different commodities. Data formats were essentially cloned. Certain fields were redesignated and coded to match specific missile configurations, performance/test attributes, and endemic missile problems. It is not clear how well these data collection formats mirrored the actual missile processing procedures at that time. It is evident, however, that maintenance processing changed over the years, and that the data collection forms were not effectively modified to reflect these changes. The layout of the forms suggests that major emphasis

was placed on the logic of their development. The forms are systematic and appear to be complete. Nevertheless, approval of the forms seems to have been based solely on their logical appearance and apparent completeness rather than rigorous user proof testing. While the logical steps of maintenance processing are apparent, there are no clear definitions of the actual maintenance procedures. For instance, processing personnel were told to fill out a form every time a missile was tested, although the actual meaning of the word "test" was not clearly defined. Later studies showed severe discrepancies between the data of the three weapon stations [Ref. 8]. Today, the antiquated format and the tendency not to fully complete records leads to significant losses of vital data.

G. CHANGING MAINTENANCE POLICY

It is appropriate at this point to digress and discuss missile maintenance in the early 1970s and its impact on the MDCS subsystems. One of the primary contentions of this report is that a basic system and the management information system designed for that system are intimately related. The management information system must mirror, summarize, and predict the outcome of the processes inherent in the basic system. It follows that if the processes within a system change, its management information system should be modified accordingly.

H. IMPROVED REARMING RATE PROGRAM (IRRP)

One of the biggest changes in maintenance policy occurred in 1966 when CNO instituted the IRRP. Many features of this program impacted ALM maintenance. For the first time, missile inventories were stored as AURs. Except for

Missile On Aircraft Tests (MOAT), maintenance and testing of missiles in the Fleet was eliminated. In addition, missiles were tested as AURs at the weapon stations. The benefits of the IRRP were many, and their impact on ALM maintenance was significant, if delayed. The IRRP was prolonged since its essential features required major modification of aircraft carriers. IRRP capability was immediately incorporated in aircraft carriers built subsequent to 1966. Retrofit of existing carriers took much longer, the last being the USS INDEPENDENCE in 1981. The transition from section to AUR based maintenance was a gradual one, taking place throughout the 1970s, both in the Fleet and at the weapon stations.

The first major impact of the IRRP was the virtual elimination of the majority of Fleet I-level maintenance. While it took some time to convert over to the AUR concept, it was obvious from the start of MDCS development that Fleet MDCS subsystem requirements had been minimized. If there was no ALM maintenance performed in the Fleet, then there was little requirement to have a system to collect data concerning that maintenance. While data forms and an instructional manual were developed for the Fleet MDCS, in reality it was never really implemented. Type Commands resisted implementation of Fleet MDCS even in those Fleet units which were still performing significant amounts of Fleet I-level maintenance. Although the Marines were purportedly testing all SPARROW assets in their possession at 90 day intervals, a survey of MDCS files for the years 1974 and 1975 identified only three appropriate records. MSIs aboard carriers for the period 1976 through 1980 continually revealed the absence of any MDCS documentation in the Fleet.

I. TEST PRIOR TO ISSUE (TPI)

In the early 1970s, ALM maintenance was dominated by a scheduled maintenance requirement defined as TPI. The TPI requirement specified that weapon stations only issue RFI assets to the Fleet which had previously been tested within a specified period of time, usually 180 days. This requirement prevented the stockpile of RFI missiles and forced weapon station workloads into a cyclical pattern in order to meet specified carrier onload requirements. In effect, the TPI requirement prevented the centralization of ALM maintenance management. In addition, weapon stations were forced to work with stocks on hand (both RFI and non-RFI assets) to meet loadout requirements. Except for budgeting constraints, weapon stations operated in a more or less autonomous fashion. Neither NAVAIR nor its designated agents had a significant amount of control over the actual scheduling of ALM processing at the weapon stations. Under this mode of processing, weapon stations operated comfortably, although inefficiently, using their own internal files, information systems, and sometimes physical inventory of magazines.

The requirements for Shore MDCS under the TPI mode of operation were really not very significant since it did not have any management information function at all. Weapon stations operated autonomously and had their own data files. Missile processing had become almost automatic: all missile sections were tested prior to issue. Consequently, the weapon stations had little need for any additional data except the explosive component service life information. Reporting of missile processing was accomplished via subsystems other than MDCS. Under the TPI mode of operation, Shore MDCS functions appeared to collect data which could used for specialized investigative analyses (e.g., how many missiles were currently configured with rocket motors that would

expire in the next year). There was some intent to use MDCS data to characterize maintenance pipeline processes, but this was more historical in nature (e.g., 26 percent of the guidance/control groups tested on DPM-7 test set serial number 10 failed during FY-76).

J. MDCS DECENTRALIZATION

At this point, the relationship between the NAVAIRSYSCOM (AIR-4104), now NAVAIRSYSCOM (AIR-420), ILSS and the underlying MIS with its MDCS component merits discussion. The ILSS is best described by Revision 2 of the Program Master Plan, which was first approved in December 1974. With ILSS, NAVAIRSYSCOM (AIR-4104) attempted to define its functions so that they could be decentralized to field activities. The ILSS Program Master Plan takes a formal systems engineering approach in the definition and control of subsystems. The ILSS and its subsystems were given life cycles similar to hardware. A subsystem's life cycle phases were related within a Work Breakdown Structure (WBS) matrix. The phases within the ILSS life cycle were:

1.	Research	WBS 1000
2.	Analysis and Integration	WBS 2000
3.	Design	WBS 3000
4.	Operation and Evaluation	WBS 4000
5.	Full Scale Implementation	WBS 5000
6.	Maintenance and Control	WBS 6000

The revision stated that the first three phases (with certain exceptions) had been completed and that the "major tasks to be accomplished were in operation and evaluation, full scale implementation and maintenance control" [Ref. 9]. Specifically, MDCS was one of the ongoing "reporting" systems which had successfully completed development concurrently with the research phase of ILSS (1972). By 1974, the planning for the remaining phases of ILSS was extensive. The completion of the test and evaluation phase (WBS 4000) required documentation

validation, specification validation, and performance and demonstration at both the system and subsystem levels, along with a final assessment. The WBS tended to imply that deficiencies uncovered during test and evaluation would be corrected prior to, or during the full scale implementation phase. NAVAIRSYSCOM (AIR-4104) selected four problems to demonstrate ILSS capability:

1. NWS and NARF workload coordination;
2. Inventory projection;
3. Evaluation of changing maintenance concepts at NWS;
4. Engineering Change Proposal (ECP) evaluation.

These problems were to be demonstrated on the SHRIKE and SPARROW missile systems, and the BQM-34 target system. The preparation of the system level demonstration plans and procedures was to require completion of subsystem demonstrations and preparation of subsystem inputs to the system level demonstration plans. WBS 4131 was supposed to demonstrate that "the MDCS is capable of providing the correct information from all maintenance levels" Ref. [10]. These words infer that it was known at the time that MDCS did not provide the correct information from all maintenance levels since Fleet and Depot MDCS were inoperative, but perhaps had the potential of providing such information.

K. ALM AVAILABILITY PROGRAM

The true state of MDCS at the end of 1974 cannot be determined. Tests and demonstrations of the system were apparently never run. The ILSS program appeared to be generating excessive expense and absorbing a considerable amount of top management effort during a period of congressional concern over defense spending. Moreover, the mandate to decentralize NAVAIRSYSCOM (AIR-4104) functions had by this time lost considerable impetus. In fact, during 1975 and 1976, some functions which had been delegated to field activites were reabsorbed. As a result, the ILSS tended to lose significance as NAVAIRSYSCOM

management turned its attention elsewhere. Some elements, particularly PMS and ICS design, were nevertheless pursued. However, the overall system demonstrations were not performed or thoroughly evaluated. Had they been performed, the need for MDCS reform and improvement would have been evident much sooner.

At the direction of CNO, NAVAIRSYSCOM (AIR-4104) instituted the Increased ALM Availability and Reduced Maintenance Burden Program in July of 1976. This program took advantage of the potential offered by the IRRP to significantly change the maintenance process for ALM. The increased ALM availability program had many attributes worthy of discussion and resulted in significant improvements in missile availability and in a reduction of maintenance expense. The increased ALM availability program was to be implemented immediately by the PACMISTESTCEN. The maintenance status of a large portion of the inventory was to be changed based on existing data. The TPI requirement was changed to SIST requirement for the majority of the inventory. This change in scheduled maintenance requirements led to the capability to stockpile RFI missiles, and ultimately to centralize and control the management of I-level maintenance. Increased emphasis was placed on monitoring the efficiency of the maintenance system in terms of AROs. Significant improvements in AROs were to be obtained largely through improved management techniques. In addition, scheduled maintenance was to be minimized by increasing SIST to the extent justified by test data. This mandate presupposed a cause and effect relationship between maintenance and missile reliability, which ultimately placed demands on the type of data which was collected and analyzed.

The increased ALM availability program was initiated in July 1976 and implemented within 90 days. Initial guidelines for changes in ALM maintenance

procedures were issued via message in July. The brevity of the message and the resistance of personnel at the weapon stations led to controversy during August. Visits were made to all three of the weapon stations in an attempt to resolve both real and imaginary problems brought about by the new initiatives.

The first real challenge to the increased ALM availability program came with the offload of the USS RANGER on 28 August. Program directives had specified that during offload (implying on board the carrier), ALM assets requiring weapon station maintenance were to be segregated from RFI missiles. The SISTs for the RFI missiles were to be extended and marked on the missile containers in terms of revised MDDs. The people who were implementing the program decided that it would be impractical to establish SISTs for RFI missiles on board the USS RANGER, largely because they did not have access to the required MDCS (configuration summary form service life) data from FLTAC. Therefore, the decision was made to return all of the USS RANGER assets to WPNSTA Concord for segregation.

During a ten day period starting on 11 September, a large number of SPARROW and SIDEWINDER missiles (80 percent of the USS RANGER inventory) were turned around and sent to the USS CONSTELLATION without significant maintenance processing. Accomplishing this turnaround required use of the main missile processing building at Concord. Missile containers had to be opened to get at the MDCS configuration summary forms which had been packed with the missiles. The USS RANGER turnaround was considered a tremendous success because it rapidly made a large number of assets available and saved the Navy an estimated quarter of a million dollars in processing costs. The USS RANGER turnaround also taught the personnel who participated in it a lesson. The turnaround could have been conducted on board the carrier had appropriate data been available.

The second offload to be sentenced was the USS KENNEDY in December 1976. Starting in October, PACMISTESTCEN personnel requested MDCS data for the USS KENNEDY offload from FLTAC. FLTAC did not respond with any data. Personnel from NWS Yorktown accomplished the turnaround on board the USS KENNEDY using data extracted from the weapon station files. The turnaround was also a success except for some SHRIKE and WALLEYE assets which were erroneously sentenced for weapon station processing because it was not realized that the service lives of some explosive components had been extended. The first USS KENNEDY turnaround proved that container markings were not an adequate basis for sentencing missiles.

L. MSI PLANS

Missile sentencing aboard carriers for the period 1976 through 1985 and the corresponding MSI plans are appropriate subjects for this discussion since they probably represent the most extensive and most prolonged examination of MDCS data in existence. In the spring of 1977, PACMISTESTCEN began formalization of MSI procedures with the publication of an instruction. The primary feature of this instruction was that an individual MSI plan would be generated for each carrier. These plans were necessary since the required data was not available and sentencing rules were too complex to allow simple missile sentencing in carrier magazines. In effect, the plans pre-sentenced carrier inventories based on maintenance data. On board inspectors were there to verify the condition of missiles and to tag containers. Exceptions were to be recorded in MSI plans. The following data was required for the preparation of MSI plans:

1. Carrier inventory and deep stowage status, which was obtained from the Conventional Ammunition Integrated Management System/Serial Lot Tracking System (CAIMS/SLIT).
2. Missile test dates and service life data, which was be obtained from the Shore MDCS subsystem.

The MSI plans tracked inventories and predicted the results of carrier offloads from the time the missiles were onloaded until they were offloaded, usually a period of a year. The active MSI plans combine to represent a large percentage of the Fleet inventory at any given time. In time, MSI plans became an effective management information system, if not officially recognized as part of the NAVAIRSYSCOM (AIR-420) MIS.

At first, MSI plans were generated by hand. In 1978, however, efforts were made toward their mechanization. Automation of the plans facilitated periodic update. During 1977, hand written lists of MDCS data required for MSI plans were submitted to FLTAC. Mixed results were obtained from these submittals. Sometimes there was no response; other times the data was too late to be useful. Most of the time the data appeared to contain too many errors to be of any value. In efforts to obtain a better response from FLTAC, PACMISTESTCEN adopted the practice of requesting data via message with information copies to NAVAIRSYSCOM. FLTAC interpreted these messages as an aggressive move and communications broke down for a while. A rapprochement was achieved in 1979, when for the first time, the two organizations began working together. A special file known as CROSSDECK was set up under the ICS subsystem, enabling PACMISTESTCEN to enter serial numbers of assets which required MSI data. FLTAC was able to transfer these lists, screen MDCS files, and input the required data into the appropriate ICS file for retransmission to PACMISTESTCEN. This ICS file worked fairly well and requests were generally completed within a week.

For the first time, relatively large amounts of Shore MDCS data were scrutinized continuously. At first the data appeared to be incredibly bad, especially for recently loaded assets. However, over a period of time it became apparent that at least the test dates and service life data were intact and reasonably accurate and complete. The major problem was that FLTAC required an incredibly long time to get the data loaded into the UNIVAC computer.

This long delay was nominally six months, but varied significantly. Even with the improved turnaround of the ICS CROSSDECK file, which had direct access to the primary MDCS files, the user was deprived of the last six months of weapon station data. Rather than admit that their collection system was inadequate and slow, FLTAC had been feeding PACMISTESTCEN obsolete data from previous maintenance cycles of the assets. The use of obsolete data was not limited to MSI plans, and probably occurred with most requests for MDCS data. The only accurate data obtained during this period was for those maintenance problems (requests for data) which viewed maintenance from a delayed historical viewpoint. With the development of SIST, the improved ALM availability forced asset maintenance into a two to three year cycle.

From a maintenance management point of view, the only important data was that which pertained to the current cycle since it reflected the maintenance status of the current inventory. The leisurely inclusion of data into Shore MDCS files dramatically compromised the picture that MDCS provided of this cycle. This slowness had a rippling effect. Not only were users deprived of six months of the most recent data, but they were instead fed the last six months of the previous cycle. The problem seems simple, but these effects were not obvious from isolated requests for data. Programs such as MSI

planning exposed the slowness of data input. MDCS data supplied for initial carrier onloads was incredibly bad. This data usually indicated that all assets loaded on the carrier, except those which were crossdecked, should be non-RFI. It was only as the carrier deployment progressed that MDCS data finally improved through monthly requests for data updates. By the time of asset offload, the data was fairly accurate.

The delay of data input into Shore MDCS is probably the second most important failure of that subsystem during the last half of the 1970s and into the 1980s. The slowness was important in its own right since it severely compromised the effectiveness of the subsystem. Of more significance, however, the delay was never officially acknowledged. The inability of management to recognize the problem probably contributed more toward MDCS subsystem damage than can be justified. FLTAC analysts were well aware of the extreme delay of data input to MDCS. FLTAC management tried to avoid the issue of the delay when possible, and defended themselves by stating that they had done their job by collecting the required data. If it was bad or erroneous, they blamed the weapon stations for not reporting the required data. If pressed, FLTAC management stonewalled and would admit to the two month delay between receipt of MDCS forms and the time data was entered into UNIVAC files. This generalization was consistently caveated with a further rationalization that data input had been currently curtailed due to the lack of funding. As such, data input became driven by FLTAC/NAVAIRSYSCOM (AIR-420) controversies over funding. The nominal two month delay in data input at FLTAC implied that the weapon stations were at fault in getting the data forms to FLTAC. Most users tended to reject this implication since they could obtain copies of the collection forms within a week of their generation at the weapon station.

As stated earlier, users of Shore MDCS data were slow to discover the extreme delay in loading the data into UNIVAC files and its impact on any resultant analysis. Isolated requests for data usually resulted in no data, or what appeared to be bad data. By the time the delay was discovered and its impact recognized at PACMISTESTCEN, efforts were well underway toward developing maintenance management subsystems which would project and predict maintenance pipeline processes years in advance. The development of SIST had given the weapon station the capability to stockpile missiles, and therefore the capability to schedule weapon station workloads. This, in turn, led to the capability to centralize maintenance management. On the other hand, CNO's difficult AROs necessitated increased maintenance management to achieve the required objectives. The development of these maintenance management subsystems centers around another subsystem within the ILSS known as Workload Coordination (WLC). WLC was defined as a subsystem of the ILSS Planning, Programming, and Budgeting System (PPBS), a distinct system from the NAVAIRSYSCOM (AIR-4104) MIS.

M. MAINTENANCE MANAGEMENT

The ILSS allowed NAVAIR to delegate the WLC subsystem function to PACMISTESTCEN in the fall of 1975. One of the primary functions of WLC is to generate a Workload Execution Plan (WEP), which projects the ALM commodity workload requirements for I- and D-level maintenance at specific activities for the next five quarters. Originally, the WEP was generated by hand and required extensive liaison with Fleet and shore based activities to determine existing and anticipated Fleet loadout requirements and weapon station inventories. In 1975 and 1976, the WEP was marginally accurate in predicting

next quarter workloads, although projections for ensuing quarters were not given much credence.

The improved ALM availability program placed significant pressure on increasing the accuracy of WEP projections. Initially, however, the initiatives of the program, particularly the automatic SIST extension and on-site inventory of unserviceable assets at weapon stations, made the WEP projections highly inaccurate. The competition between the WEP and the improved ALM availability program created animosities within particular factions at PACMISTESTCEN for control of the maintenance management of ALMs. By the spring 1977, personnel involved with MSI plans realized that the plans could be combined to form a more effective basis for WEP projections. At the time, WEP projections treated all offloaded assets as non-RFI while MSI projections separated assets as both non-RFI and RFI. Some of the RFI assets would be crossdecked and not returned to weapon station inventories.

To some extent, the hostilities mentioned above prevented integration of MSI and WEP efforts at PACMISTESTCEN. The major factor preventing integration was that both MSI plans and WEPs were generated by hand. The great amount of effort, detail, and need for constant revision made the integration unfeasible at that time. Nevertheless, a major breakthrough occurred in February 1978 when the Ships Parts Control Center (SPCC) agreed to start sending PACMISTESTCEN monthly tapes of CAIMS/SLIT. With these tapes, PACMISTESTCEN began to quietly automate MSI plans. One of the things these tapes revealed was that missile status at the time of carrier onload and current MDDs were more accurately depicted in SLIT than in equivalent MDCS data. To increase the accuracy of the MSI plans, PACMISTESTCEN tended to ignore FLTAC MDCS input for the early stages of deployment and used slightly different SLIT data instead. To defend their position, PACMISTESTCEN argued that MDCS data was incorrect.

In February 1978, SPCC also began shipping monthly CAIMS/SLIT tapes to FLTAC for some undetermined reason. This tape was converted into a UNIVAC file, supposedly so that FLTAC could verify MDDs listed in SLIT records. It is not known how much of the SLIT data FLTAC used. To conform to the CNO mandate not to maintain duplicate data bases, little effort has been expended toward integrating SLIT and MDCS data. The integration of this data is, of course, one of the fundamental prerequisites of a viable NAVAIRSYSCOM (AIR-420) MIS.

By the fall of 1978, PACMISTESTCEN had completed automation of MSI plans. Their execution from that time foward became an increasingly routine matter. PACMISTESTCEN informally transferred control of MSI plans and they became a WLC function. With this transfer, MSI plans became the driver for the WEP. Once the MSI plans became a WLC function, there was no longer any objection to their use as a basis for the WEP.

At the same time, AROs of several primary assets declined drastically. NAVAIRSYSCOM (AIR-420) started remedial action including revision or redefinition of the ILSS in the form of the NAWMP, purge of the CAIMS/SLIT data files, institution of more accurate data reporting by CONUS activities, and finally, increased emphasis on management of maintenance processing. As part of the latter effort, NAVAIRSYSCOM (AIR-420) issued tasking to FLTAC to develop an automated WEP. This assignment was an afront to PACMISTESTCEN management since the WEP was considered part of their WLC subsystem. PACMISTESTCEN quietly started automating the worksheets which comprise the WEP, one by one. Efforts at FLTAC to develop an automated WEP floundered during 1979, 1980, and 1981. It appeared that they did not properly understand the maintenance processes underlying the WEP nor the data elements necessary to characterize those processes.

In reality, obtaining this understanding was a simple matter. The WEP worksheets were in fact road maps and plans on how to construct an automated WEP. FLTAC did not want to import PACMISTESTCEN technology, but preferred to develop a new system of their own. By attempting to develop a new system, FLTAC took a significant chance. The PACMISTESTCEN had carefully tailored their system to mirror existing ALM maintenance processes. To deviate from the WEP or its underlying processes was to deviate from reality and introduce error. One of FLTAC's fundamental mistakes was to attempt to drive their automated WEP wherever possible with MDCS data. In this application, MDCS data was simply not pertinent; MDCS does not contain the data required to develop a viable WEP. In 1981, the FLTAC effort to develop an automated WEP was cancelled with little if anything accomplished. The WEP had already been automated at PACMISTESTCEN.

The futile attempt by FLTAC to develop an automated WEP pinpoints a third more fundamental and philosophical problem with MDCS: the system probably contains very little data which can effectively be used in a NAVAIRSYSCOM (AIR-420) management information system. Although MDCS files contain the elements described in its documentation pamphlets, they are now obsolete. Fifteen years have elapsed since MDCS was designed to reflect a maintenance system that was autonomous and inefficient by today's standards. That maintenance system has not existed for ten years, yet there has been little fundamental change in MDCS. The concepts of decentralization and the separation and specialization of data bases have severely handicapped MDCS. MDCS may indeed characterize maintenance actions carried on with significant detail, but it does not reflect the overall framework of the process. In terms of the original intent as described OPNAVINST 4790., MDCS must be considered a

significant failure. It has little 3M utility either in the management of material or the maintenance thereof.

By current standards, the WEP cannot be called an effective management information system either. It is, in fact, an automated, periodic report with no mechanized interactive or distributive capability. However, the WEP is one of NAVAIRSYSCOM AIR-420's most effective maintenance management tools. The success of the WEP can be traced to the fact that it indigenously mirrored processes which its users wished to control. Emphasis was placed on characterizing procedures, not data. Users were free to select data from available sources. If MDCS had contained the best data, it would have been selected. It turned out that the CAIMS/SLIT data was of greater utility. Today the WEP is a fundamental part of the NAVAIRSYSCOM (AIR-420) maintenance management function. Although the WEP could be improved with further modernization, it should be utilized as a cornerstone in the development of a new MMIS.

One final aspect of the improved ALM availability of 1976 which bears on MDCS was the mandate to "extend SIST to the extent justified by data." This mandate assumed that there was a causal relationship between the time interval at which scheduled maintenance was performed and the amount of failures which could be expected in Fleet inventories. This idea has considerable merit although it was later shown that failure rates were, to a considerable extent, time independent. The importance of the mandate was that it called for a new type of analysis or utilization of data which the ALM maintenance community was ill prepared to perform. Neither the existing maintenance processes nor data systems had been designed to evaluate such problems. To perform these analyses it was necessary to characterize certain aspects of maintenance.

1. <u>Fleet Exposure of Assets</u>

This data might have been available had Fleet MDCS been operational. Instead, PACMISTESTCEN collected this data during execution of MSI plans.

2. <u>Asset Failures During Processing</u>

This data was available in Shore MDCS via ICS after significant time delays. It was often more effective to obtain copies of MDCS processing forms directly from the weapon stations.

3. <u>Part Failures During Depot Repair</u>

This data may have become available in depot MDCS. The extreme time delay between failures in the Fleet and the part repair at the depot precluded this step in analysis.

4. <u>The Cause of Part Failures</u>

The ALM maintenance process does not contain any provision for true failure analysis. Weapon Quality Evaluation Centers (WQECs) are sometimes funded on a missile by missile basis to perform such analysis. The resultant data is usually not contained in any data base, except possibly, AWCAP. SIST extensions were finally accomplished for SPARROW and SIDEWINDER missiles in 1981 based on completion of steps 1 and 2 in the process noted above. The ultimate causes of failures or the reasons for the time independent failures were never determined.

N. DEPOT MDCS

Previous discussions have centered primarily around Shore MDCS. It is appropriate to briefly document the history and status of the third subsystem, depot MDCS. The ILSS recognized the need for data subsystems for each of the three levels of maintenance and had initiated their development in 1972. The

second revision of the ILSS Program Master Plan, dated December 1974, also claimed that development of all three MDCS subsystems was complete and test and evaluation would soon be implemented. As stated earlier, however, this test and evaluation never took place. It was also apparent that the development of depot MDCS was behind its Shore MDCS counterpart to some extent. The depot MDCS documentation manual was being circulated in draft format while its shore counterpart had been approved.

In 1975, depot level maintenance of ALMs consisted primarily of repair of SPARROW (AIM-7E) and SHRIKE (AGM-45) components at NARF Alameda and repair of SIDEWINDER (AIM-9G) components at NARF Norfolk. Planning was in progress for depot level repair of emerging missile systems at various prime contractor sites:

1. STANDARD ARM (AGM-78A) operational (1969) - General Dynamics, Pomona.
2. PHOENIX (AIM-54A) operational (1975) - Hughes Aircraft Company, Tucson.
3. SPARROW (AIM-7F) operational (1976) - Raytheon Corporation, Lowell.
4. HARPOON (AGM-84) operational (1977) - McDonnell Douglas, St. Louis.

The first major problem with the depot MDCS was that its implementation was initially delayed and sporadic depending on the missile system in question. In 1975, FLTAC leased Mohawk terminals and contracted operators to perform coding at NARF Norfolk. It is noteworthy that these terminals were to transmit data directly to the FLTAC UNIVAC. Data was collected on forms generated by NARF Norfolk, so they had some control over data elements and coding. From all reports, operations at NARF Norfolk were fairly successful. They were superseded, however, by a decision in 1976 to curtail SIDEWINDER repair at Norfolk concurrent with the deployment of the AIM-9H. In contrast to Norfolk, NARF Alameda resisted attempts to implement MDCS at their site. Alameda had developed its own internal reporting system and considered MDCS an unnecessary

imposition. NARF Alameda successfully delayed the battle, arguing that formats and coding were awkward and unusable. The relative autonomy of NARF Alameda prevented direct imposition of MDCS reporting. It is believed that NARF Alameda did not consistently begin reporting until 1979.

Depot MDCS reporting for the other missile systems was even more sporadic. During the period of 1976 through 1978, emphasis was placed on controlling and centralizing management of I-level maintenance at weapon stations. Weapon stations were considered the vulnerable link and the area where the most improvement could be obtained in terms of the ARO. Accordingly, depot level maintenance and depot level reporting were given less emphasis. It was not until 1979 that individual studies of the AIM-54A and AIM-7F systems and generalized SIST modeling proved that the slow turnaround of assets at depots had significant impact on asset availability.

NAVAIRSYSCOM (AIR-420) has less control over depot level repair performed by prime contractors than it does with the remaining portions of the ALM maintenance system. In the first place, prime contractors are strongly motivated by NAVAIRSYSCOM (AIR-05) development and acquisition contracts. While prime contractors consider depot repair efforts to be lucrative and necessary, they are certainly secondary to the major acquisition contracts. In addition, depot level repair efforts are often tied to major support contracts of which NAVAIRSYSCOM (AIR-420) does not have full control. Most prime contractors prefer to utilize their own data systems and tend to view MDCS reporting as an imposition. Experience indicates that NAVAIRSYSCOM (AIR-420) has had difficulty in enforcing MDCS reporting requirements on prime contractors performing depot level maintenance. Records for the periods in which Hughes Aircraft Company performed AIM-54A maintenance are spotty in MDCS. McDonnell Douglas resisted

all attempts to include HARPOON depot level repair in MDCS until 1981, at which time they dumped four years of data on FLTAC. The result was a mass of unintelligible and unverifiable data which has never been sorted out. Apparently, SPARROW AIM-7F and STANDARD ARM AGM-78A data from Raytheon and General Dynamics have never been incorporated in depot MDCS. Although the utility of depot MDCS is an open question, the subsystem has never been fully implemented and does not contain the data that it was designed to collect.

O. SOURCE DATA AUTOMATION

The discussion now turns to the history of the Source Data Automation Network (SDAN) and its predecessor, the SPARROW Information Network (SIN). SDAN was a FLTAC effort to improve one of the major problems associated with Shore MDCS: the extreme delay in incorporating data in MDCS files. The failure of SDAN or at least the extreme delay (nine years) in making SDAN operational has in effect precipitated the current controversy over the utility of MDCS in NAVAIR ALM maintenance management functions.

As early as 1975, individuals at the working level believed that MDCS had significant problems and were voicing their criticism. This was also the time when advances in Transistor-Transistor Logic (TTL) technology had led to the introduction of the relatively low cost of minicomputers. The minicomputer provided an alternative to centralized computer information systems. Distributed networks of small computers with interactive capability were now feasible.

In the fall of 1976, a group of individuals from NAVAIR, PACMISTESTCEN, and FLTAC proposed that a new maintenance data system should be developed in conjunction with the scheduled introduction of the SPARROW AIM-7F into the

Fleet in the spring of 1977. The group was funded and had the support of the SPARROW Program Manager, Air (PMA). Since the system was funded by the PMA, it was designed to support a single missile system--the SPARROW. As mentioned previously, the new maintenance data system was to be called the SIN. For its time, SIN included many innovative features, including:

1. Reassessment of MDCS data elements to assure their utility in management and logistics functions. Unofficial estimates indicated that at least fifty percent of MDCS data elements could be eliminated with no significant loss of function.
2. Absorption of vital data elements from other data systems such as SLIT.
3. Redefinition of data elements to reflect maintenance processes.
4. Development of a missile traveler based on punched card technology to simplify data collection processes.
5. Implementation of a distributed network of computers throughout the ALM maintenance community to speed data input to a central data agency; allow direct user access to central data agency files; allow development of user files and processing to specific site requirements.
6. Allow interactive communication between all members of the network.

In their zeal to obtain acceptance of their program, the advocates of SIN were quick to cite the inadequacies of MDCS. NAVAIRSYSCOM (AIR-4104) interpreted these actions as a direct attack on its management policies, its data systems, and its supporters throughout the ALM community. NAVAIRSYSCOM (AIR-4104) did not like the attack initiated by the advocates of SIN, but there was a more fundamental problem. NAVAIRSYSCOM (AIR-4104) required a single data system controlled by its delegates to encompass all ALM assets. A proliferation of data systems acquired, and perhaps controlled by political advisaries such as the PMAs could not be tolerated. While SIN had significant technical merit, it had to be destroyed for political reasons.

The major battle over SIN took place at FLTAC in the fall of 1977. The FLTAC advocates of SIN were judged to be insubordinate due to their continued support of the program and were transferred to positions having nothing to do with ALM maintenance. Simultaneously, NAVAIRSYSCOM (AIR-4104) supporters at FLTAC were given charge of an improved MDCS system which was to incorporate

many of the features of SIN. In the fall of 1978, FLTAC circulated a draft specification of the improved MDCS system to activities within the ALM maintenance community for review and comment. PACMISTESTCEN's primary reservations at the time [Ref. 11] were:

1. Review and modification of MDCS data elements had been eliminated;
2. It was unclear that users would have direct access to central data files;
3. In particular, the equipment to be installed at PACMISTESTCEN appeared to have little or no data processing capability.

In a strange turn of events, FLTAC requested that PACMISTESTCEN personnel assigned to NAVAIR-05 responsibility review the document. NAVAIRSYSCOM (AIR-04) representatives were not directly consulted. As a result, PACMISTESTCEN's concern was never directly conveyed to its NAVAIRSYSCOM (AIR-420) sponsor. On the other hand, the PACMISTESTCEN NAVAIR-05 representatives believed that their desires were being listened to.

In 1979, FLTAC initiated prototype testing of a network by installing PRIME computers at Corona (a PRIME 750) and at the Fallbrook Annex (a PRIME 450). Efforts were restricted to the transmittal of MDCS data of SPARROW missiles processed at Fallbrook to FLTAC Corona. This prototype testing encountered significant problems. Initially, there were problems in training personnel to operate the terminals. Secondary problems occurred with the definition of data elements and the reliability of validation routines and dictionaries. Hard copy forms remained as the the primary mode of MDCS data collection.

In 1981 and 1982, FLTAC expanded the network by installing PRIME 450 computers at WPNSTAs Concord and Yorktown. In addition, efforts were made to expand data collection to cover processing of SIDEWINDER and later, HARPOON missiles. The same problems which had occurred at Fallbrook also occurred at Concord and Yorktown. In addition, however, discrepancies started appearing

between data which had been obtained through processing the collection forms at FLTAC and that which had been transmitted via the PRIME network. Errors were not consistent since the validation procedures were not perfect. The increased amount of data flowing into FLTAC taxed the PRIME 750 storage capability. Rather than having a stand alone capability, the PRIME 750 became the front end processor for the UNIVAC 1108. Differences in the PRIME and UNIVAC operations systems created problems with data processing software and data file structures.

In 1982, FLTAC changed the name of the network from the Improved MDCS System to SDAN and indicated that it was a component of MDCS primarily intended to eliminate the extensive time lag involved in processing input data. MDCS users, particularly at PACMISTESTCEN, felt they had been betrayed. Although FLTAC was finally admitting to one of the primary faults of MDCS, it was still not being eliminated. Due to the interface problems, data was only being transferred from the PRIME to the UNIVAC in the form of batch processing at lengthy intervals of time. To users who interfaced with the UNIVAC data, input appeared as slow as ever. In addition, SDAN had become a data collection mechanism to a data system which no longer had any credibility. FLTAC had stripped all of the data reform and interactive capability from the network.

In 1983, relationships between FLTAC and PACMISTESTCEN took an additional turn for the worse. When pressed about plans to expand the network, FLTAC representatives refused to admit that there had ever been plans to include PACMISTESTCEN in the network, and had no plans for installing a computer at PACMISTESTCEN in the future. PACMISTESTCEN was to be restricted from any direct access to data files and would be allowed only the preprocessed reports

from FLTAC. Such a situation was unacceptable to any individual at PACMISTESTCEN who felt his function required access to maintenance data.

According to the NAWMP, as of February 1985, I-level reporting of SPARROW, SIDEWINDER, and HARPOON maintenance is performed via SDAN, with plans for adding the remainder of the air-launched missiles and expanding the capability to include depot level reporting. The majority of MDCS reporting is still done using forms originated in 1975 (and subsequently revised). In the fall of 1984, NAVAIRSYSCOM (AIR-420) requested evaluations of SDAN as a means of assessing of the viability of MDCS. In October 1984, NAVAIRSYSCOM (AIR-420) drastically curtailed funding for the operation of MDCS and has tasked both PACMISTESTCEN and FLTAC to initiate remedial actions toward development of a new or redesigned MDCS.

V. CONCEPTUAL MMIS CHARACTERISTICS

This section presents material of a conceptual nature concerning the characteristics required for a new MMIS. The section is divided into two subsections. The first describes technology transfer principles which should be applied in the development of a new information system. These principles, although philosophical in nature, are considered more fundamental to the successful development of a new system than technical requirements. The second section lists conceptual technical requirements for the new system.

A. TECHNOLOGY TRANSFER PRINCIPLES

Technology transfer has emerged as a discipline to evaluate and improve the flow of information between a variety of entities, including individuals, organizations, systems, and perhaps machines. The application of this discipline to information systems is especially appropriate since they are contructed, or require the integration, of all of the entities noted above. The flow of information is a critical factor not only in the information system itself, but in its conception, design, acquisition, evaluation, and operation. Although the principles of technology transfer may be considered philosophical in nature, they are perhaps more fundamental to the development of a new system than any of its physical or technical attributes. Failure to consider the principles of technology transfer could easily result in a disaster at some stage in the information system's life cycle.

Technology transfer is a topic directly related to the development of a new MIS. Most of us think of technology transfer as the flow of our newly

generated ideas, information, and methodologies to someone who can or will put them to use. Obviously, this is directly applicable to the MDCS, and therefore the MIS. Neither of these systems are functional due to the specific lack of information transfer. Based on this deficiency alone, the system should be foresaken. A closer look at the basic tenets of technology transfer provides some guidelines by which to design a new MIS.

Within the air-launched missile logistics support system, there has been a tendency to interpret information transfer as instructions, documentation, and structured reports. The NAW[illegible] is an example. Technology transfer, however, occurs only when people work. Unless there is evidence of people's work output, there is no way to measure how much technology or information has transferred. While written reports and documentation are necessary, and in some cases vital to the success of new technology, they are certainly not the yardstick of technology transfer. Most likely, management personnel accepted this interpretation because documenting and disseminating information were thought of as efficient procedures for transferring information.

As developed by Professors J.W. Creighton and J.A. Jolly of the Naval Postgraduate School, technology transfer is defined as a "purposive, conscious effort to move technical devices, materials, methods, and/or information from the point of discovery or development to new users" [Ref. 12]. Thus, the result of technology transfer may be the user's acceptance of a common practice, or it may be a different application of a technique designed originally for another use. Two things must be apparent for transfer to take place. First, the user must have a clear knowledge of the practice or application required. Because communication or linkage between the user and the developer is not always close or effective, the urge is strong for the developer to do

what he/she wants rather than what the user requires. Since the MDCS was designed by FLTAC, many of its features do not serve its NAVAIRSYSCOM users. As with most innovations, the design of the system was an evolutionary process, including several system changes over a long period of time. For example, when a new missile entered the maintenance pipeline, the system was modified to incorporate its data. Soon, immense quantities of data were being collected but very little was being utilized. There was, and still is, very little control over the design of MDCS reporting elements.

Secondly, the design of an innovation must demonstrate that the capability of the system actually offers substantial advantages to the business. Thus, simply disseminating information is not enough for technology transfer to take place; the information must offer rewards for its use. Information will only be sought to the extent that it is useful, and utilized to the extent that its value exceeds the cost of obtaining it. The manager values the information when it assists in decision making, otherwise the information has no value. Since there is a perpetual queue of information waiting to be assimilated outside of our minds, a transfer mechanism which recognizes the limitations and necessity of data dissemination must continually be defined. In other words, the source data for an innovation must fill the user's requirements in order for it to serve as information for a problem solution.

In their studies of the technology transfer process, Creighton and Jolly developed what they call "The Linker Model," which identifies a list of necessary factors for the movement of technology or information from a source to a user. The linker is the individual or organization which links the source and user organizations; this is probably the most important factor in the transfer of technology. Linkers mediate between the user and developer organizations

and attempt to connect the user's requirements with the developer's output. The concept of the linker essentially enforces the idea that good communications are highly important to successful technological innovation.

The linker's importance cannot be overemphasized. The lack of a linker during the initial development phases of the MDCS has certainly contributed to the system's collapse. The various modules of the system, which were intended to reflect the maintenance pipeline, were all designed and supported by different units within FLTAC. These units were fairly autonomous in their operation, and consequently the modules evolved to the point where one could not communicate with the other. For example, if you wanted the complete maintenance history of a given missile, you would have to request data from each FLTAC unit. FLTAC would then trace back through the system to form an integrated missile history. This, of course, was time-consuming and expensive.

Although the job of the linker is by no means an easy one, bypassing it is an assurance that the innovation will fail. By not employing a linker while developing MDCS, FLTAC generated a system to fit their needs and desires, rather than those of the maintenance managers who used the information. In developing a new MMIS and MIS, the system should be designed using the following elements of the technology transfer linker model:

1. <u>Selection Of Project</u>

This factor refers to the selection process of an innovation. In the case of MDCS, experience has shown that the basic reason for the user's inability to work with the data is because the selection process was done by others trying to perceive what the user needed rather than he wanted. In other words, the research for the project has come before the client's needs. In an optimal state, however, there should be a two way flow of information to both parties.

2. Information Documentation

This element defines the format, language, and complexity of an innovation's documentation. The format and language must be of a level where it is understandable by the user. One cannot utilize information that he cannot interpret.

3. Information Distribution

Technology must flow from the source to the user in order to find application. The new MIS would depend on the number of entries and sophistication of computer technology. The success of information distribution can be measured when people with problems can reach people with potential solutions. As noted previously, relations between NAVAIRSYSCOM user activities and FLTAC leave a lot to be desired.

4. Technical Credibility

Credibility is an assessment of the information's reliability as perceived by the user. Since many users have trouble differentiating the source of information from the channel through which it flows, the user must carefully analyze the two elements before taking action. How the potential user perceives the information is crucial to the adoption or use of the technology. With MDCS, the data is viewed as faulty information owned by FLTAC rather than NAVAIRSYSCOM or weapon stations.

5. The Linker

As noted earlier, the linker is the key factor in technology transfer. Linkers are not necessarily superior technical people, but are instead the sources of knowledge.

6. Formal Organization

This element defines the formal organization of the information user, and his/her perception of his/her position within the organization. The

attitudes of these individuals often describe the overall character of the organization. However, the design of an organization should also be considered when developing new innovations. For example, the Navy comprises a matrix of organizations, many of which need to be considered in order for technology to be adopted.

7. Individual Capacity

Capacity refers a new user's potential to make use of new skills and information. This is an especially relevant factor when considering computer systems such as MDCS, which may or may not require the addition of new skills. When designing a new MMIS, a great deal of thought should be applied to whether or not weapon station technicians should input data.

8. Reward/Penalty

The way in which a user observes the rewards (or lack of) affects considerably his/her own creativity and the adoption of new innovations. Extrinsic rewards, such as good working conditions and a healthy salary, are obvious to most of the working community. Nevertheless, intrinsic rewards, such as intellectual stimulation and recognition among peers, are considerably more effective toward motivating people to be creative and efficient. For the MDCS user, one must question whether there is a reward in using the information. Is the user recognized for making decisions based on the information?

9. Willingness

This element refers to the user's ability and/or desire to utilize the data or information. Successful adoption of an idea might take a long period of time from the instance when it was accepted intellectually. There are many reasons for the delay. Many people simply resist change and its rippling repercussions. With MDCS, the users' failure to use the data

immediately cancels any transfer of information. FLTAC's resistance to upgrade the system demonstrates their apparent laziness, but also proves the effects of financial change and organizational competency. Successful information transfer is contingent upon all of these elements. Forfeiting any one element detracts from the effectiveness of technology transfer.

The MDCS should serve as the linking mechanism between the source of maintenance actions and the manager of the maintenance system. Rather than operating as a series of complex communication channels, the system should involve those performing maintenance with those managing maintenance. Linking the two sides is the vital element. When the user of an information system can be termed at the interface point between information output and need, the system is called a linker of source and user.

B. TECHNICAL REQUIREMENTS AND SYSTEM OPERATION

Although there are many conceptual models that can be developed for new MMIS, during this study the author developed a MMIS conceptual model which is presented in the following paragraphs. The MMIS should have the following technical requirements:

1. The system must be controllable and auditable.
2. The system must have integrity.
3. The system should be economical to operate.
4. The system must be user friendly.
5. Data must be collected on-line as missile maintenance status changes.
6. Inquiries must be answered with up to the minute information.
7. The system must interface all information users with suppliers of data.
8. Missile quality assurance and input data quality assurance must be linked.
9. The system must be fail soft.
10. Special skills or extensive schooling should not be required to run the system.
11. User programming should be optional.

The new MMIS would be a distributed system with a central data base containing a Data Base Management System (DBMS) and a Decision Support System

(DSS). The DBMS would provide software, hardware, and organizational techniques to manage the data base. It would also prevent data redundancy and make efficient use of storage space. The DSS would be designed to provide organized methodology for the solution of semi-structured problems through qualitative or quantitative inputs. The DSS would be designed to assist the decision maker in the semistructured environment under study, while reserving to the decision maker the unstructured aspects of a problem. This implies a DSS that is user friendly with a minimum of technical terminology used in the interface.

The computer system would be arranged in a star network with a host computer and a number of satellite Distributed Processing Systems (DPS) as illustrated in Figure 4. Each DPS would transmit and retrieve data from the host computer, and on a selected basis, update the host data files. The DPS users would also be able to make their own analysis of data files read from the host computer. The host computer would maintain all present missile configurations, integrated maintenance histories, present status summaries, and maintenance pipeline locations. Missile configuration could be read from the host and printed put as travel packages. It is visualized that the system would operate in the following manner:

1. <u>Construction of Missile Traveler</u>

Upon the build-up of newly manufactured missile sections, the weapon station or commercial production facility would construct a standardized missile travel package. The travel package would contain all necessary data elements concerning that particular missile. The package would contain separate forms for each major assembly (i.e., motor, warhead, control and guidance section). Data from the travel package would then be input into the appropriate

host computer data files. This process would create the initial file for that particular missile and would establish its present configuration and condition.

2. Comparison of Data Files

Travel packages for missiles returned to weapon stations would be removed and compared with the data files from the host computer to insure data consistency. Any discrepancies would be cleared before maintenance actions are performed.

3. Verification of Data

After determining that the travel package is correct, the missile would proceed through the maintenance process in accordance with the Industrial Processing Guide (IPG). The travel package would be updated by the missile maintenance personnel as maintenance actions are performed. At each quality assurance point, the quality assurance inspector verifies that the maintenance had been properly performed, verifies data entries, and updates host computer files. The host would be updated on a real-time basis. Each time data is entered, the host computer checks all data elements for validity, and records the quality assurance inspector's identification for auditability. This process would assure correctness of data entered into the host computer.

4. Depot Rework Procedures

When a missile section is sentenced for depot rework, the appropriate data form is removed from the travel package, updated, entered into the computer, and forwarded with the section to the depot where the same processes are performed by depot maintenance personnel.

5. Hard Copies of Maintenance Data

If a travel package is lost, a new one can be generated by the host through inquiry made by the DPS. When travel packages are filled to the extent

that no more data can be recorded, a new serialized package is generated by the DPS and the old travel package is forwarded for microfilming and archive storage. This process provides hard copy backup to the system.

6. Data Entry

Data entry could either be by a centralized data terminal within the maintenance facility or by optical character reading devices at centralized locations within the maintenance facility.

7. Missile Deployment History

A missile's deployment history would be contained on a form within the travel package. O-level maintenance personnel would complete the form during deployment, but the data would not be entered into the computer until the missile returned to the weapon station. MSI teams would insure that forms are filled out for the missiles utilized in Fleet deployments.

Use of the travel package described above is merely an innovation on the missile logbook and the configuration summary forms that have been used for years. The new travel package system offers several advantages. The travel package would move with the missile. All the redundant data would be pre-printed. The maintenance personnel would only check off or add changes. The leave package broadens the scope of quality assurance to include data entry. Entry times and dates would be recorded by the computer during data entry. The travel package could be designed to follow the IPG and would be compared against its standards. There would be one set of forms, both for recording and accessing data by both Fleet and shore facilities.

C. MMIS CONCEPTUAL ISSUES

This concept contains a litany of issues that might suggest that the travel package and distributed system concepts are inadequate in meeting

requirements; that they are too complex, too difficult to manage, and too subject to risk and failure. On the contrary, the advantages outweigh the disadvantages. A distributed system is more robust. It would not be dependent on a single processor, a single manager, or organization. The system is more natural. Local functions are handled locally, rather than transferring great amounts of work to a central site with the consequent loss of local ownership and control. The distributed system links users of the information with the inputers of the data, provides for quality assurance of the data, hard copy backup, continually crosschecks new input with previous input, instantly updates maintenance actions and maintenance status, and allows for exception reporting to name a few advantages. The disadvantages include greater design sophistication and an unforgiving pressure on the local environment for reporting accuracy which could create problems in terms of project management. The distributed system will require higher levels of user skills and greater attention paid to planning for both data collection, form design, data input devices, DPS capability, the people involved, and their organization.

D. STANDARDS OF PERFORMANCE

Standards of performance enable management to control the production process. Distributed networks and travelers mirror the maintenance processes, and can play an important role in gathering and comparing actual performance data with established standards and reporting discrepancies for management by exception. As presently constituted, the MDCS does not have any programmed standards or mechanism to make performance comparisons except by manual means.

In recent years, NAVAIRSYSCOM (AIR-420) has developed standards for the production process. These industrial engineering studies, referred to earlier as IPGs, measure times required to perform the maintenance processes at the weapon stations. However, these standards are not programmed into the MDCS or its resultant information systems. Therefore, the managers must make their own decisions concerning what is or is not a maintenance problem. For example, none of the test equipment has established standards for nominal failure rates nor has there been any way of comparing maintenance actions or missile failure rates between different weapon stations.

In 1981, PACMISTESTCEN commissioned a study to establish and analyze failure and rejection rates of SPARROW missiles as a function of testing on AN/DPM-21 test sets. The analysis contained 5811 individual SPARROW test records. These test records were extracted from MDCS files on magnetic tapes provided by FLTAC. With a sample of this magnitude, the objects of the study should have been met and some nominal standards developed for the AN/DPM-21 SPARROW missile rejection rates. However, due to MDCS data inconsistencies, missing data elements, erroneous source coding, bad operation codes, and non-standardized reporting practices, the study was not entirely successful in establishing failure rates of the different tests sets to determine if there was any kind of standardization.

A critical factor in the maintenance process is Mean Logistics Downtime (MLDT). This is the time the missile remains in the maintenance pipeline while waiting for a repair action to take place. MLDT seriously impacts asset readiness. At present, the only way MLDT can be determined is to manually track missiles through the maintenance process.

Figure 5 is an AUR/section flow diagram for the maintenance of an air-launched missile. The complexity of the network makes computerized standards extremely valuable in the management of the maintenance process. Use of the computer is the only feasible way of calculating and measuring performance of the maintenance system. Standards should be developed to measure and control the performance of the maintenance pipeline, and these standards should be programmed into any future MDCS.

VI. AVAILABLE TECHNOLOGY

> A revolution is underway. Most Americans are already well aware of the gee-whiz gadgetry that is emerging in rapidly accelerating bursts from the world's high technology laboratories. But most of us perceive only dimly how pervasive and profound the changes of the next twenty years will be. We are at the dawn of the era of the smart machine, an "information age" that will change forever the way an entire nation works, plays, travels and even thinks. Just as the industrial revolution dramatically expanded the strength of man's muscles and the reach of his hand, so the smart machine revolution will magnify the power of his brain.
>
> Newsweek, June 30, 1980

A. EFFECTS OF TECHNOLOGY ON MANAGEMENT

As the role of computers in organizations has matured, supporting the needs of the manager has become an increasingly important function. In certain fields such as maintenance management, the requirements of the job demand the efficient use of the computer. But if information departments are to effectively fulfill the needs of the present day manager, they must develop systems which managers view as appropriate to their needs. Often it is preferable to develop a new system rather than being constrained by obsolete technology and methodology in the modification of an existing system.

Although the development of a new MMIS is a challenging assignment, it is a necessary move for NAVAIRSYSCOM users. Until recently, the main problem for organizations using computers was obtaining the adequate technology for the desired application. The current maintenance management community requires the generation and implementation of a new system which responds faster and is broader in scope than the current MDCS. Despite FLTAC's inefficiencies in controlling the data base and output devices, many managers still view the computer as essential to the organization. The technology to improve the system is available now. Developmental problems are strictly managerial.

Management of the system should become the responsibility of the user. For too long users have suffered from FLTAC's ineptitude. As the designated CDCA, FLTAC has attempted to accumulate NAVAIRSYSCOM maintenance data, although in most cases it is in a form that is unidentifiable and therefore useless to its users. The problems with the current MDCS must be approached from two angles. First, FLTAC is governed by NAVSEASYSCOM, a competing Naval activity. While communication is never a simple process, dealing with an organization which follows its own set of rules can often times be chaotic. In this case, FLTAC is concerned only with the operation and maintenance of the system rather than the value the data represents to NAVAIRSYSCOM logistics managers and engineers. FLTAC's basic premise seems to be, "It's your data, we only collect and store it."

In fact, this statement is true; the data belongs to NAVAIRSYSCOM and FLTAC's job is to collect and store it. However, NAVAIR engineers and managers will not accept ownership of the data, nor will they attest to its credibility so long as FLTAC continues to run the show. This, of course, results in continuous inter-organizational conflicts, and more importantly, a total lack of control over NAVAIRSYSCOM's information resources.

The political ramifications of this problem have been lengthy and far-reaching. Over the past ten years, there has been an increasing effort to decentralize computer resources, including the differentiation of software from hardware, and the diffusion of technical expertise. Traditionally, the computer has been kept in a centralized, and often jealously guarded, organizational location. But with the advent of large-scale telecommunications networks, and mini- and microcomputers, the capabilities of the machine have been brought to the user. Although this progress will aid in the development

of alternative information systems, it does not alleviate current relations with FLTAC, who have resisted the transfer of authority and information. Communications specialists tell us that when a competitive threat has grown great enough, there will be a resulting willingness to take the risks inherent in adopting a new technology. This is NAVAIRSYSCOM (AIR-420's) current position. FLTAC has created boundaries which separate users from their own "exclusive" data. And in so doing, they again point out that the dependence of others serves as the basis of power.

B. COMPUTER DEVELOPMENTS

As stated previously, computer technology is constantly changing. In the last several years, hardware advances have been incredibly rapid. There have also been similar though less publicized software improvements. Today, the generation of adequate software determines the speed and accuracy of computer based applications. As a result, computer software is an increasingly more important consideration than computer hardware.

However, both are necessary considerations when developing any kind of computer system. Although the technologic advances in computer science have been almost immediate, this perpetual frenzy of innovation has left many computer buyers with obsolete systems. The PRIME 450 computers presently used at the weapon stations are examples. With an increasing number of effective computers on the market, the actual worth and utility of the PRIMEs is in question. In comparison to the computers of today, the PRIME is outdated. Today's personal computers can probably fulfill the majority of user requirements, and some can even surpass the capability of the PRIME 450s.

With the abundance of items on today's computer market, it is easy to buy a computer. How intelligently the computer is used ultimately depends on planning, which in turn depends on a clear knowledge of the business. In designing and buying a new system, it is also important to realize that the ubiquity of the computer demands the efficient reporting and storage of data. Many people no longer wish to see lengthy dissertations analyzing raw data. They'll analyze it themselves. The use of computers in our society is quickly reaching the point where to remain competitive, you must use a computer to aid not only in storing data but in making decisions. As a buyer of new computer hardware systems, NAVAIRSYSCOM (AIR-420) must also remain current with the computer industry in an effort to stay abreast of even further innovations. For example, at the present time, developmental efforts continue toward "talking" to computers rather than typing the required information. There has been considerable achievement in this area and society cannot help but wonder when it will finally be consummated.

The effects of this new technology and others like it on the maintenance community should be considered when purchasing a new system. Although the PRIME computers can still provide the information required, they are much slower to work with than a modern microcomputer. Advances in the design of microprocessors have led many users to expect data to be processed in real-time.

C. SYSTEM ALTERNATIVES

As an alternative to a real-time system, batch processing is also available. However, "batching" information means that the user does not have access to the computer's CPU. In batch mode systems, processing requirements

are collected at a central site, sorted, and processed as the computer has time. Batching obviously reduces the timeliness of reporting information, which in the case of MDCS, has been a determining factor in estimating the system's worth. However, as opposed to on-line processing, batching is much more economical. In addition, it is an effective application when the delay caused by queuing data does not reduce the value of the information. On-line processing involves different degrees of processing speed. For example, a system may combine immediate on-line access for inquiries to the data base with batch mode operation for periodic update of records from a central collecting agency or remote site. Hybrid systems satisfy many requirements and are simpler and less expensive than real-time systems, which require the CPU to handle all inputs, outputs, and record updating immediately through on-line terminals.

Timesharing is a term used in the computer industry to describe a processing system with a number of independent, relatively low-speed, on-line terminals. Each workstation has direct access to the central processor. Multiprogramming allows the CPU to switch from one station to another, doing part of the job required by each. However, the speed of the machine allows the user at each terminal to feel as if he/she is the only one using the computer. The power of the CPU in comparison to the complexity of its tasking determines how close service approaches real-time. Many organizations are now using minicomputers in their timesharing system. This enables many different types of work to be accomplished at one time, including word processing, document filing, telecommunications, and various kinds of data processing.

Organizations which require constant communication with other offices use computer networks known as distributed processing systems. When these dispersed computers are connected by a communications network, the offices may

then transmit messages, processing tasks, and other informational data. The distributed processing network is actually an extension of timesharing, and enables its users to share some of the most significant software available today. This, of course, reduces the amount of idle CPU time, making the system more cost effective than a regular single user real-time system. With this increased availability of computer resources, many managers have easier access to the data and are therefore more readily prepared to make decisions for unusual problems.

Unfortunately, the processing speed is often slower. Since the distributed system operates on the same essential premise as the timesharing system, the CPUs are constantly switching around to handle all tasks. As the number of users and associated complexity of processing requirements increases, the speed with which they are processed decreases. In addition, the costs of the distributed system may not always balance the quality of the computing service. One last potential disadvantage of the distributed system is its provision for protecting the confidentiality and integrity of user programs and data files. Although security programs are constantly improving the protective qualities of current systems, the methodology for cracking security systems is perhaps progressing at a faster rate. Of course, this does not mean that every type of distributed system is accessible to anyone. Once the decision is made to include classified data in the MMIS, security requirements significantly increase distributed system cost and complexity. It is believed that tradeoffs will finally indicate that a hybrid system should be developed wherein nonclassified data will be distributed and handled on-line while classified data is processed batch mode off-line.

As noted previously, one of the primary flaws of the MDCS data base is a lack of complete records. Data bases require that report elements be clearly

defined and consistently organized. In turn, this requirement demands that someone in the organization be given the authority to standardize or approve any necessary changes to the data elements. Control of the data leads to control of processing the software. With the advent of application software such as data base management, many users are now able to query the data base in a desired format without any particular knowledge of programming.

As evidenced in the computer industry today, a user with a clear and well defined application to his problem can generally find a wide range of technical building blocks. And although the jargon of the computer industry, "computerese," may inhibit new users, there are many users with a clear sense of what computers do and how development projects must be managed.

VII. MANAGEMENT SYSTEMS APPROACH

The systems approach to be employed for the development of the MMIS will consist of four phases: (1) the Study Phase, (2) the Design Phase, (3) the Development Phase, and (4) the Operational Phase. Each phase will be subjected to an iterative process of review and will result in a final output that can be used for determining the achievements gained by the activity. Figure 6 represents the life cycle of the system and products that will give utility for judging the results of each phase. The management approach will be results oriented.

A. THE STUDY PHASE

This phase is the initial effort to define the overall MMIS strategic plan and development of a systems performance specification. The effort will result in the assignment of a data base manager, establishment of a study team, and execution of a fact finding process. During this phase, the requirements for data and report formats will be identified and input/ output requirements will be established. The development of system flow charts and the selection of the most practical equipment (considering what is already available) will occur.

The study phase will culminate in a System Performance Specification (SPS), which describes the objectives of the system, identificaton of the internal and external constraints (such as existing equipments that must be considered for use) and a feasibility study on the use of converting currently collected data into required reports. Another significant product of the study phase is

the MMIS Life Cycle Management (LCM) Plan. The plan will be a dynamic tool that will identify the manpower and resource requirements necessary to implement and operate the MMIS throughout its life cycles.

B. THE DESIGN PAHSE

The SPS developed under the study phase establishes the basis for further effort in the design phase. The primary effort under the design phase is to evaluate performance requirements and perform trade-off studies with current computer technology. The efforts performed in the design phase will extend and expand the first and second tier systems defined in the study phase, and will consolidate hardware and software functions. A Design Specification will be prepared that delineates the system's architecture required to satisfy performance requirements and will include MMIS decisions as follows:

1. Determination of manual and equipment functions/operations;
2. Hardware and computer interface requirements;
3. Type and functional programming requirements;
4. Data base design;
5. Storage media, processing requirements, and access requirements;
6. System and programming test requirements;
7. Identification of distributed processing requirements.

The design phase will conclude based on approval of the Design Specification and acceptance of an updated/revised MMIS LCM Plan.

C. THE DEVELOPMENT PHASE

There are seven principle tasks to be performed during the development phase of the MMIS. They are:

1. Internal/external computer programming (external is required in a distributive computer system);
2. Preparation of implementation plans, technical manuals, and training devices;
3. Acquisition, installation, and debugging of new hardware (if required);

4. Preparation and verification testing of system/subsystem/component performance;
5. Preparation of Systems Specification and "as built specification";
6. Establishment of hardware/software baselines and change control procedures;
7. User reviews, problem identification, and software debugging.

The basis of all these tasks lies in the Design Specification prepared and approved from the preceding phase. To ensure acceptance of the MMIS during the operational phase, a primary requirement is to use a lot of grease with all the known users. This requirement is best accomplished through the iterative process of user reviews and proper indoctrination training. Resistance is usually less when users are made part of the development process. There are two major elements of the development phase. They are:

1. Establishment of an operational system;
2. Identification and control of the system through a System Specification and change control process.

Successful completion of the first three phases brings to fruition an operational computer based MMIS. At the conclusion of this phase, the MMIS is placed into operation.

D. THE OPERATIONAL PHASE

The transition from the development phase into the operational phase is hard to distinguish. The training that is performed during the development phase overlaps into the operational phase and will continue on a periodic basis during the life cycle of the MMIS. Users will operate the system and acquire the necessary information to control the maintenance pipeline. As new systems emerge and data requirements change, it is important to implement a change system that can keep pace with the evolving requirements for new and better information.

Even though the system is operational, a continuous forum should meet on a periodic basis to discuss problems, propose changes, and monitor change efforts. On an annual basis, a team should be formed to perform an audit type inspection testing of system/subsystem/component performance to give the new MMIS a checks and balance system to ensure its integrity.

E. STRATEGIC PLANNING FOR THE IMPROVED MMIS

The degree of success of an operational computer based management information system can be directly attributed to the strategic plan used throughout the system's life cycle. The improved MMIS will require a comprehensive management plan that will consider the management strategies to employ. The strategic plan will be addressed as an LCM Plan and will provide the practical framework for the controlled growth of the MMIS.

The MMIS LCM Plan will be a dynamic tool that documents information system policy and information resource management. The plan will encompass the management structure and responsibilities, informational and equipment requirements, project activities, schedules and milestones, and cost controls. The dynamism of the plan will be represented by continual change that results from evolving innovations in technology as well as decisions associated with informational requirements. The plan will be an integral part of the MMIS and will give the foundation of total planning for effective, efficient, and affordable accomplishment of mission information system needs during the system's life cycle.

F. STATEGIC PLANNING RESPONSIBILITIES

The MMIS LCM Plan will be prepared by the lead activity responsible for Data Base Management (DBM). The NAVAIRSYSCOM should designate the PACMISTESTCEN as

the activity responsible for the MMIS DBM. The LCM Plan will be prepared and maintained current by the PACMISTESTCEN.

The PACMISTESTCEN is responsible for establishing the management hierarchy for development of strategic plans and definition of data and informational requirements. The PACMISTESTCEN is in the best position to accomplish this job since their awareness of informational needs for accomplishing mission objectives at the strategic, tactical, and operational levels cannot be matched by any other organization. The strategic plans will be formulated from every perspective with sensitivity to all levels of informational requirements, emphasizing user selectivity and accessibility.

G. MMIS DATA BASE MANAGER

The PACMISTESTCEN will organize internally to build the MMIS strategic plan and initiate development efforts. A data base manager will be assigned who has the reputation and expertise to represent the PACMISTESTCEN within NAVAIRSYSCOM and other activities. The data base manager will be required to make significant contributions to strategic planning and system development efforts by being fully aware of three key elements:

1. The composition of the maintenance pipeline currently consists of the informational requirements for effective monitoring and control.
2. Knowledge of MMIS user informational/data requirements from field and command level prospectives;
3. The ability to effectively interface with activities/commands outside the NAVAIRSYSCOM to ensure proper integration of all necessary data into the MMIS.

The data base manager will be required to make decisions relative to system formulation and informational requirements; to this avail, the PACMISTESTCEN designated data base manager will be a GM-14, temporarily staffed to the Weapons System Directorate for a period of one year during intensive initial

system development. Due to the relative significance of the initial development effort and the lack of any means of obtaining the necessary data to manage the maintenance pipeline, heavy emphasis will be placed on expediting system development that will necessitate the data base manager to be dedicated to MMIS development without collateral duties.

The data base manager will be the focal point for strategic plan development. NAVAIRSYSCOM (AIR-420) will retain policy decisions and plan approval responsibilities. The data base manager will work closely with NAVAIRSYSCOM (AIR-420) in the preparation of the MMIS LCM Plan to ensure consistency with current and future NAVAIR policies and initiatives.

H. MMIS STUDY TEAM

The data base manager will draw together a study team that will be comprised of representatives from all future users of the MMIS, computer specialists tasked with equipment and programming responsibilities, and other significant contributes to the proper development and implementation of the MMIS. The study team will be the nucleus for defining system performance requirements and will be the main contributor of the MMIS LCM Plan.

Meetings of the members of the study team will be held on a monthly basis to discuss user requirements, develop performance requirements, and to review action assignments. During the study and design phases, meetings may be called on a more frequent basis to allow for expediting system definition and development efforts. The data base manager and other study team members may elect to interview others to obtain information necessary to further understand potential areas that might require data or information, or provide a source of input data.

I. MMIS INFORMATION AND EQUIPMENT REQUIREMENTS

The reason for establishing the MMIS is to provide users with information and data in a form and frequency that will improve the maintenance management function. The identification and development of these requirements will be contained in the MMIS LCM Plan and will be done through a fact finding process that allows future users to convey their ideas and reporting requirements. The fact finding process will be accomplished by the data base manager and study team during the study phase. User data requirements will be documented in broad terms in the MMIS LCM Plan, with expanded requirements being identified in the SPS.

During the design phase, user data requirements will be measured against a number of system considerations and trade-offs. The feasibility of obtaining and producing the necessary information to satisfy user needs will be determined. The MMIS LCM Plan will be updated/revised to reflect informational decisions made during this phase.

J. PROJECT ACTIVITIES AND THE MMIS LCM PLAN

The MMIS LCM Plan will have a comprehensive section on the who, what, when, and where of all project activities required during the initial phase of system development through implementation. The MMIS LCM Plan will be updated/revised as system requirements evolve into operational status. The plan will be dynamic, even in the operational phase, by delineating events that will be required throughout the system life cycle. Examples of activities that will be addressed are future system audits and performance appraisals, new development initiatives/ system changes, and establishment of technological advancements. The MMIS LCM

an will be maintained during the MMIS complete life cycle and will be used for guidance and providing information on planned project activities.

K. MMIS SCHEDULES, MILESTONES, AND COST CONTROLS

The initiation of a master plan for establishing schedules for tasks and milestones for events is necessary. This will be accomplished through the use of a management analysis and planning network known as Critical Path Method (CPM) networking, which is similar to the Program Evaluation Review Technique. CPM graphically displays task requirements and relationships, and forces management to construct a network which will act as a master plan for accomplishing project activities.

CPM will be employed to control the complex project events associated with the development of the MMIS. The CPM network insures total planning from program initiation to the operational phase. CPM will be used to identify schedules for task activities and will project MMIS program milestones. The CPM networking process will identify a critical path which will require management focus and continual attention. The CPM networking techniques will assist the DBM in controlling loss of time and project costs.

Project costs will be results and output oriented. The MMIS LCM Plan will identify man-hour requirements and costs associated for completion of major milestones. A detailed cost analysis will be performed in conjunction with CPM network events and actual expenses will be assessed against program accomplishments. Cost projections will be refined as more definitive system requirements are developed. Cost considerations will receive the micromanagement attention to achieve program objectives within cost projections.

MAGNETIC TAPE RECORD DESCRIPTION

CARD	CHARACTER POSITION	FIELD NAME	LENGTH
1	1-20	C.I.I.D.	20
1	21-37	C.I. SERIAL NO.	17
1	38-43	C.I. DATE	6
1	44-47	C.I. TIME	4
1	48-52	"SMDCS" or "FMDCS"	5
1	53-56	REPORTING ACTIVITY	4
1	57-80	ITEM/MK/MOD	24
2	1-20	ITEM PART NO.	20
2	21-37	ITEM SERIAL NO.	17
2	38-80	MATED ITEM SERIAL NO.	43
3	1-24	MATED ITEM SERIAL NO.	24
3	25-30	ACTION DATE	6
3	31-34	ACTION TIME	4
3	35-36	OPERATION CODE	2
3	37-51	TEST EQUIPMENT TEC, SERIAL NO.	5
3	52-53	ITEM SOURCES	2
3	54-55	MATED ITEM SOURCE	2
3	56-57	MATED ITEM SOURCE	2
3	58-59	MATED ITEM SOURCE	2
3	60	TEST/INSPECTION RESULT	1
3	61	MATED SECTION RESULT	1
3	62	MATED SECTION RESULT	1
3	63	MATED SECTION RESULT	1
3	64-66	DISPOSITION CODE	3
3	67	CONDITION CODE	1
3	68	DEFECT CODE	1
3	69-72	NALC	4
3	73-80	FSCM	8
4	1-4	TEC	4
4	5-13	WUC	9
4	14-30	NIIN	17
4	31-44	LOT NO	14
4	45-49	MGFR. DATE	5
4	50-54	T1	5
4	55-59	T2	5
4	60-80	T3	5
5	I-80	FAILURE CODES	80
6	I-80	FAILURE CODES	80
7	I-6	DATE ASSIGNED	6
7	7	TRANSFERRED	1
7	8-12	TO/FROM ACTIVITY	5
7	13-80	JOB ORDER NO	68
8	1-80	REMARKS	80
9	1-80	REMARKS	80

Figure 1. PHOENIX Maintenance Record Format.

MAINTENANCE DATA COLLECTION FORM
AIR LAUNCHED MISSILE SYSTEMS (ALMS)

ACTION ACTIVITY JCN: ORG W5D | DATE ASSN 7311 | SER 5006

SPAR/7/E-2 R15887-b-2 MCBF

SAMPLE

1 | VISL | 1410-00-175-1201 PA25

DATE	TIME OF DAY	OPRN	IDENTIFICATION	HALC DODIC	TEC	WUC	SERIAL NO. REMOVED	SERIAL NO. INSTALLED	SOURCE CODE	FSCM	NO.	MFR DATE	TEST TIME				MAL CODE	DEF CODE	CODE	DISP	
7311	1400	DS	SPAR/7/E-2	PA25	MCBF	—	R15887-b-2		FC	—	—	~~00~~	—	—	—	F			M	DIS	WMP
↓	↓	RM	TSG	PM8	—	57C70	↓		↓	↓	↓	↓				A			↓	HFT	
			FCG	↓		↓	15887-b2									A				↓	
			WHD/38/0	V436		81153	1427B				97 C-68	12-68				A				HBR	WMR
			RM/38/4	V227		25180	384 ~~xx~~828				SK-329	10-72				A				HFT	
			WVGD	PW34		—	UNK				--	~~00 00~~				A				HFI	
			WING-FIN	PW95	↓	↓	UNK		↓	↓	↓	↓				A			↓	↓	

DATE	TIME OF DAY	NARRATIVE	DATE	TIME	NARRATIVE	LOCAL USE

List SPARROW being disassembled on first line. Enter all removed sections on subsequent lines.
Enter VISL in Block 11.

Figure 2. SPARROW Maintenance Action Form.

REPORT SYMBOL NAVSEA 4790-5 (78)

SHORE ACTIVITY MAINTENANCE DATA COLLECTION – CONFIGURATION SUMMARY
SPARROW III MISSILE (ALMS)
NAVSEA 4790/3 (7BS) (REV 8-77)

			DOCUMENT NUMBER: 5001	1 DATE PREPARED: 7318
2 NOMENCLATURE MK/MOD: SPARROW AIM-7 _ M5	3 TYPE	4 IDENTIFICATION NUMBER: 1410-00-520-1231	5 SERIAL NUMBER: R-4058-bH-5	6 NALC: PA70
7 ACTIVITY UIC/ORG CODE: W5D	8 TEC: —	9 JCN: W5D73185001	10 JOB ORDER/PROD WORK AUTH: 3852010	11 MAP CASE NUMBER

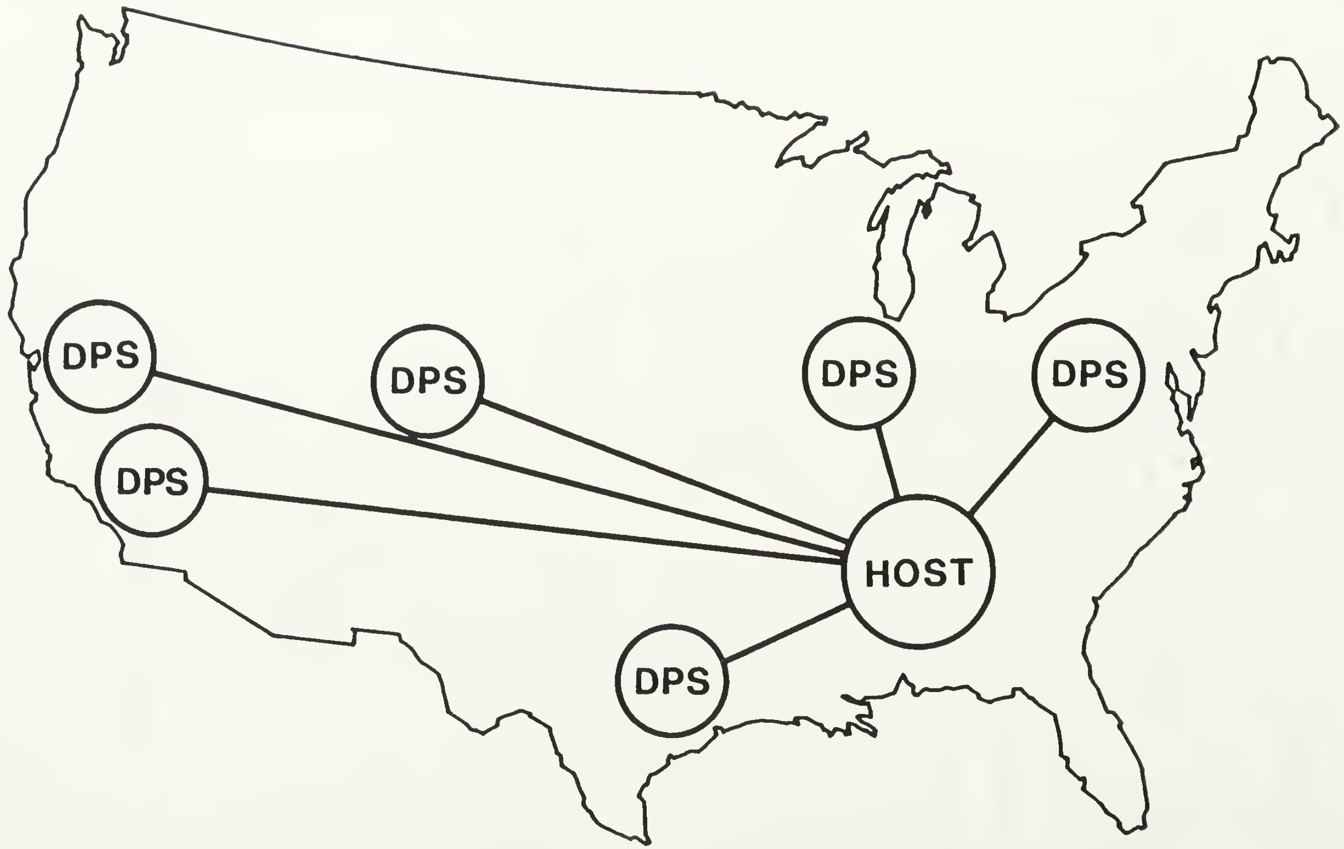
12 NOMENCLATURE MK-MOD/TYPE/DRAW-PART NO	MK	MOD	13 SERIAL NUMBER	14 LOT NUMBER	15 FSCM/MFG	16 LOAD CURE/MFG DATE	17 EXP DATE
TARGET SEEKER GROUP			R4058-bH5				
FSN							
FLIGHT CONTROL GROUP			2103 bH5				
FSN							
WARHEAD/EXERCISE HEAD	38	0	2515	29		07-64	07-84
FSN							
SAFETY AND ARMING DEVICE	35	0	129	1		12-69	12-83
FSN							
ELECTRONIC FIRING SWITCH	73	2	3761	8		12-64	12-84
FSN							
BOOSTER FUZE	38	1	—	2M		03-62	03-82
FSN							
ROCKET MOTOR	38	4	384-000866	SK31		03-69	03-79
FSN							
IGNITER	265	0	RT-36090V	1456-8		01-69	01-83
TLM							
FSN							
EPU (FUEL STICK)	UNK			PAE81870		06-69	06-81
EPU (IGNITER)				80		03-69	03-85
GPU				86		09-75	09-95
HPU-M (GAS TANK)				UNK			
HPU-M (RUBBER BLADDER)				UNK			
HPU-M (EXPLOSIVE ACTUATOR)				1-14		05-63	05-81
BATTERY (7F)							
GAS GENERATOR (7F)							
ELECTRONIC ACTIVATOR (7F)							
CRADLE/CONTAINER	470	0					
WVGD	PIV 34		1 EA				
W/F	2W 97		1 SET				
US SEALS #			95105				
			95482				

18 ALTERATIONS TECHNICAL DIRECTIVES			19 WAIVERS		
AWC-104					

20 RPI (Date – Time): 7318	21 LAST SYS TEST DATE: 7236	22 DO NOT ISSUE AFTER DATE: 8181	23 CERT UNTIL DATE: 9090

24 INSP/ACCEPT-QAP: -	25 INSPECTOR: Martin	INIT/STAMP	26 EQUIP FREQ CODE	27 TLM CODE	28 COND CODE: B

Figure 3. SPARROW Configuration Summary Form.



DPS = distributed processing system

Figure 4. Distributed Star Network.

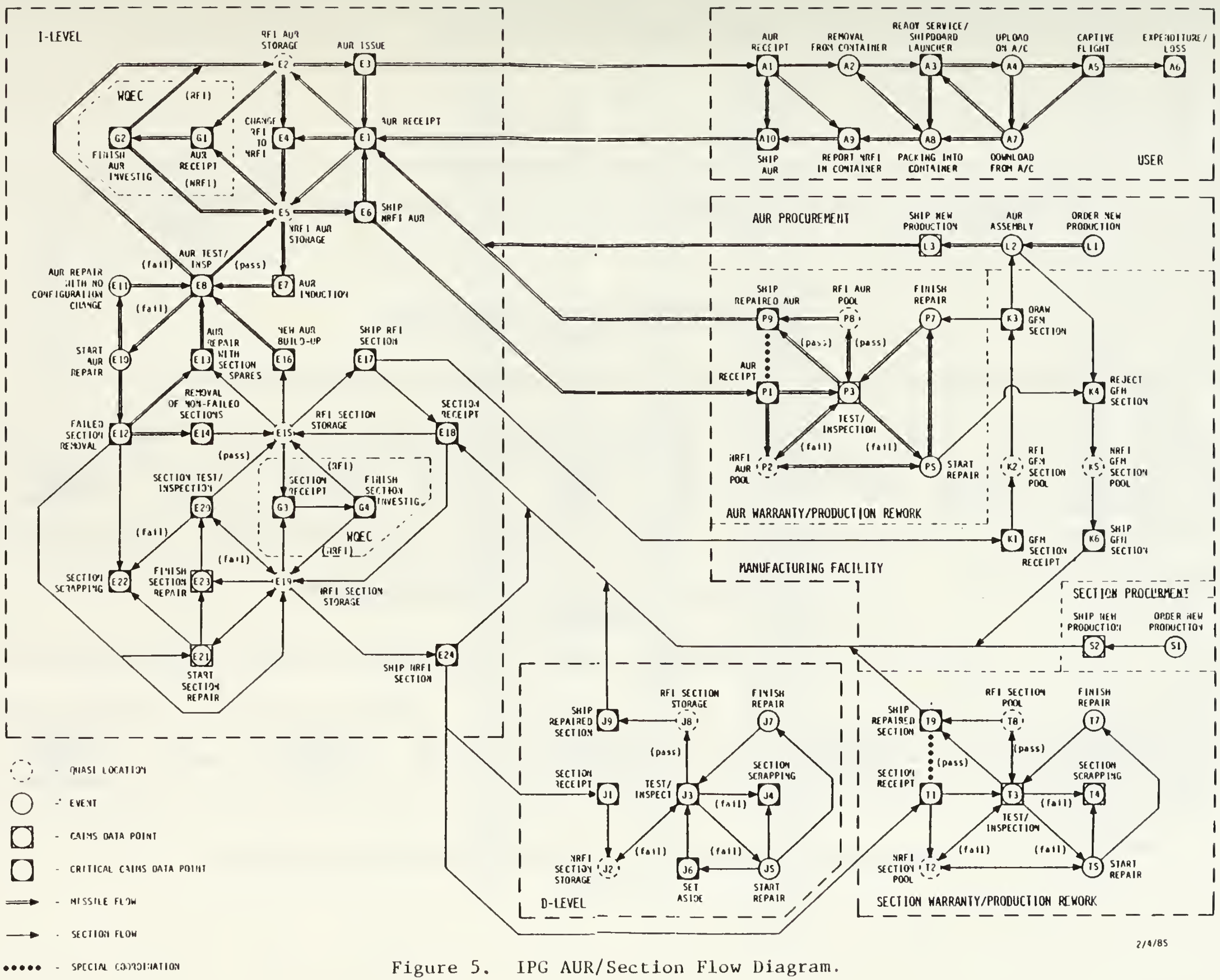


Figure 5. IPG AUR/Section Flow Diagram.

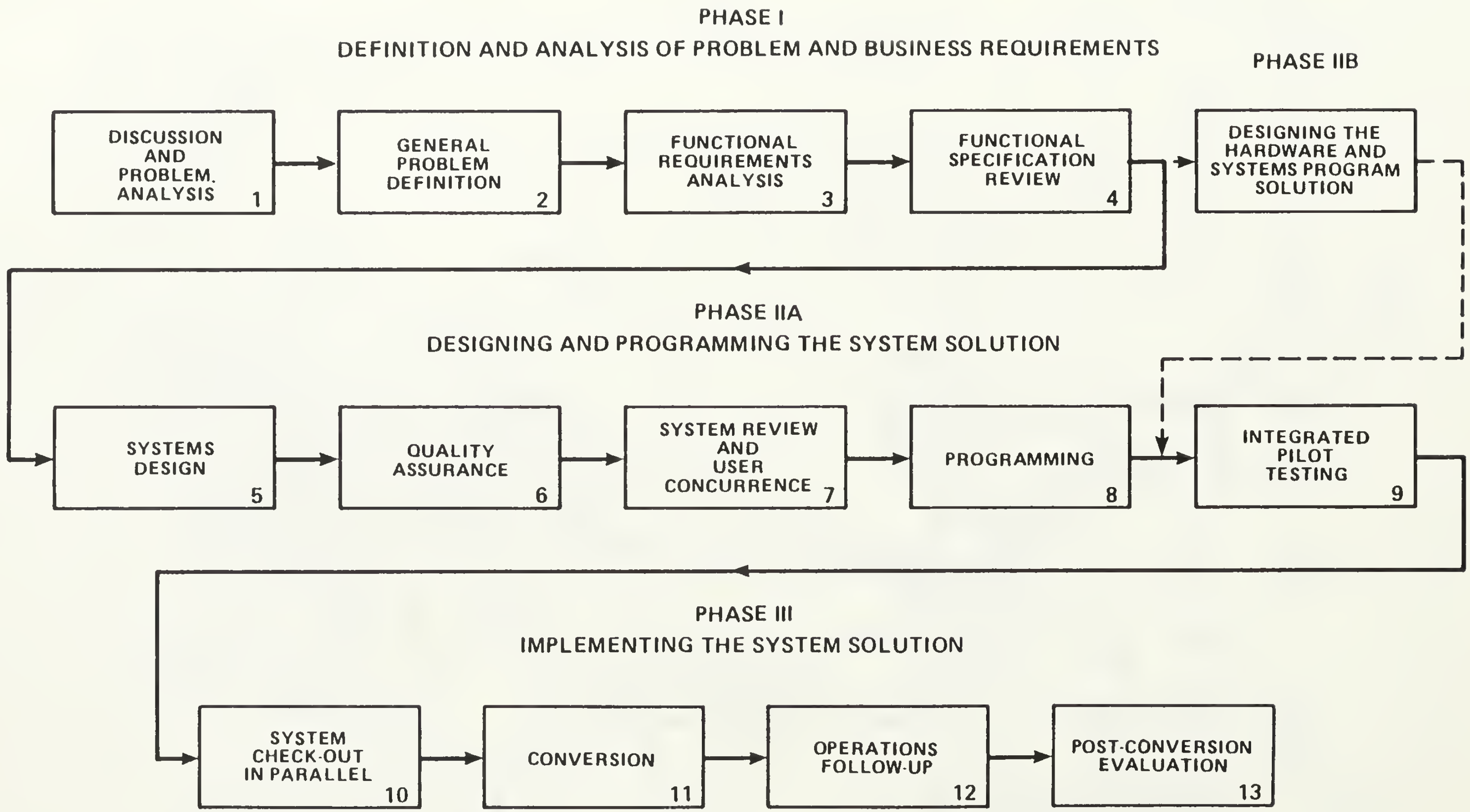


Figure 6. Life Cycle of MMIS.

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4. Ibid., pp. 6-1-2.

5. Ibid., pp. 6-1-2.

6. Ibid., pp. 6-1-2.

7. Ibid., pp. 6-1-2.

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A study for development and management of a maintenance management information system for Navy air-launched missiles.